

AD/A-003 221

LESS LETHAL LIQUID BALL

John W. Sarvis

Army Land Warfare Laboratory
Aberdeen Proving Ground, Maryland

May 1974

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Three sizes of liquid-filled balls were tested for various ballistic characteristics to determine the best size for potential use as a less lethal munition. Test results and drawings or photographs are presented.		Three sizes of liquid-filled balls were tested for various ballistic characteristics to determine the best size for potential use as a less lethal munition. Test results and drawings or photographs are presented.
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BLOCK 20. ABSTRACT CON'T

unfavorable image cast on firefighters. The Army undertook to study the use of both water cannon (not identifiable with firefighting units) and water-filled launched containers for the purpose of finding an acceptable less-lethal munition. This report describes the genesis, development, and testing of liquid-filled breakable spherical munitions in 12-gauge, 40mm and 3-inch diameter sizes.

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INTRODUCTION

In responding to a domestic confrontation situation, Army personnel armed with conventional munitions incur a certain risk that their intended restrained response may, through either happenstance or isolated malevolence, be uncontrollably escalated. There is, therefore, the necessity to have a less drastic response capability (one purposefully less-than-lethal) for those situations for which death would not be an appropriate deterrent.

The objective of this program was to develop spherical projectiles containing water or other liquids for less lethal applications. Additional effort on the less lethal area was also conducted under LWL Task 01-F-72, Less Lethal Ammunition for Small Arms. This development effort is described in LWL Technical Report No. 74-17.

DEVELOPMENT

In the beginning of the US Army Land Warfare Laboratory's (USALWL) study to find an acceptable means of quelling civil disturbance, personnel of Mobility Branch, USALWL, envisioned the use of discrete encapsulated slugs of water launched at moderate velocity to accomplish a relatively noninjurious desirable effect.

3-Inch Diameter Liquid Ball

Both Government and contractor personnel pursued the concept of discrete slugs of water in frangible spheres. A child's toy ball, the "Blue Bird" ball, available locally, was chosen for the candidate sphere. Under funding from USALWL Task 10-M-71, the contractor, AAi Corporation, Cockeysville, MD, prosecuted development of a less-lethal projectile using the 3-inch diameter toy ball as a basis. The ball material was ethylene vinyl acetate. The ball, having a skin thickness of from 0.030 inch to approximately 0.090 inch at the seam, was scored to a depth of 0.025 inch, filled with water, and glued to a cuffed cylindrical styrofoam and homosote sabot for retention purposes (See Figure 1).

This assemblage was designed to be fired from an existing launching system vended by the service contractor for firing their 3-inch diameter riot agent dispensing grenade (See Figure 2). This existing system is composed of a standard 12-gauge riot gun, an L-110 launcher, and a tangent sight mounted on the riot gun. The launch is powered by a C-200 blank cartridge, also vended by AAi Corporation.

In 1971 USALWL requested the then-operational US Army Small Arms Systems Agency (SASA) to have the Biophysics Laboratory at Edgewood Arsenal perform comparative hazards studies to assess the probable worth of further effort on the 3-inch diameter Liquid Ball (at that time referred to as the Water Ball). The Edgewood Arsenal study consisted of a series of shots at gelatin filled skulls and liver and lung organs of goats and baboons. Test projectiles were the Rubber Bullet, a device used by the United Kingdom; the Stun Bag; and the USALWL Water Ball. The UK Rubber Bullet appeared hazardous to a range of approximately 63 feet (difficult to pinpoint exactly due to erratic velocities). The MBA Stun Bag appeared hazardous to a range of 85 feet. The results from the USALWL Water Ball, however, were more encouraging and indicated hazard to only about 7 feet. (Refer to Edgewood Arsenal Biophysics Laboratory Report EB-TR 73056, by Heieck and others.) SASA recommended further work on the liquid-filled frangible sphere due to its relatively low hazard.

The concept was pursued further by Munitions Branch, USALWL, which was then engaged in evaluation of salient commercial less-lethal munitions and certain other new concept items. To determine quickly that optimum size of Liquid Ball which was most effective and least damaging, it was decided to investigate the tactical, flight, and impact characteristics of three different sizes. The sizes, corresponding



Figure 1. Less-Lethal Liquid Ball, 3-inch Diameter

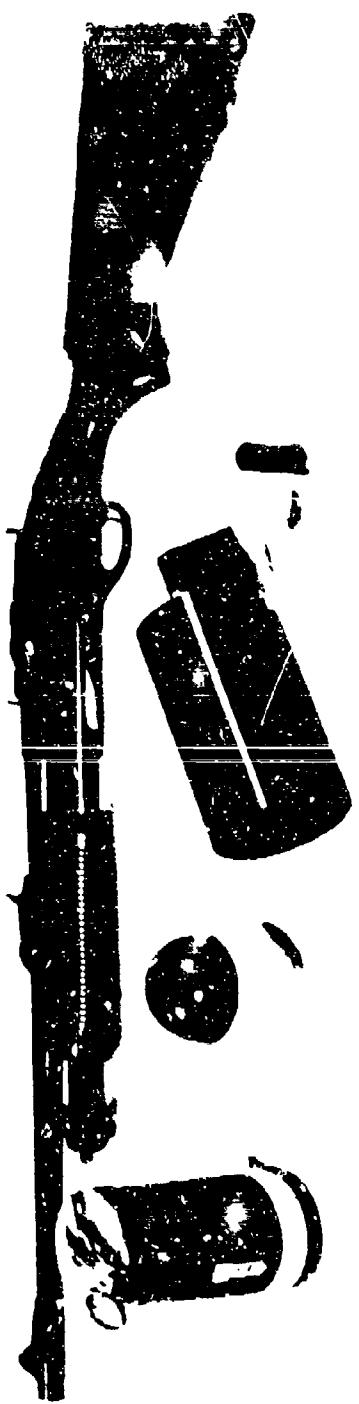


Figure 2. 3-inch Diameter Less-Lethal Liquid Ball,
Launch System Components, and Commercial Grenade

to available launch mechanisms, were those which would fit 12-gauge, 40mm and 3-inch guns or launchers. Because of the environmental considerations associated with military items, the filler material (100% water) had to be replaced by a liquid which would not become solid (and lethal or unusable) when stored at extremely low temperature prior to use in a northern CONUS location. Of the various candidate fillers, a mixture of glycerine and water appeared best to permit low temperature storage and tactical employment, to insure a minimum of public objection, to prevent harmful physiological effects to user and target, and to minimize certain risks if the munition were a candidate for adoption into the Army inventory.

A work assignment under an existing contract with AAI Corporation was executed for fabrication of 500 of the 3-inch diameter Liquid Balls having the improved filler. The contractor provided a 60% glycerine and 40% water filling for the serrated balls. Specific gravity of the mix was about 1.2. The weight of the filled ball was 265 grams + 3 grams. The contractor also provided drawings (see Appendix A). The depth of the two normal diametral serrations was kept at 0.025 inch. The burst energy of sample projectiles was about 3.5 foot-pounds. Because of the large variation in skin thickness in the balls, this burst energy figure was variable.

Loading and firing the launch system for the 3-inch diameter is clumsy and time-consuming--a tactical disadvantage. The sequence is as follows:

1. Place the butt of the gun on the ground and, grasping the L-110 Launcher or the riot gun barrel to steady it with one hand, insert a Liquid Ball into the mouth of the launcher with the other hand. Press firmly down on the Liquid Ball forcing the sabot to engrave into the rifling of the launcher bore.
2. After raising the gun to waist height and holding the gun horizontal at the balance with the left hand, place a blank cartridge into the chamber with the right hand. (The short blank C-200 cartridge must be manually loaded for reliable operation.)
3. Shoulder the loaded and charged launcher and riot gun and then sight and fire.

Because of the care required to avoid rupturing the ball while forcing the sabot to engrave into the rifling, a rate of fire of only about 3 shots per minute was experienced.

40mm Liquid Ball

Another work assignment under the same R & D contract provided for development of a 40mm version of the Liquid Ball. The final design is shown as an assembled cartridge (see Figure 3). The ball itself is a serrated glycerin and water-filled ping-pong ball. This celluloid type ball material is 0.015-inch thick and is serrated on two normal diameters to a depth of 0.010-inch for easy fracture upon



Figure 5. 40-mm Liquid Ball Cartridge (cutaway)

target impact. Impact fracture consumes about 0.7 foot-pounds of energy. (Refer to drawings in Appendix B.)

12-Gauge Liquid Ball

A 12-gauge Liquid Ball was designed, fabricated, and tested by USALWI. The projectile had the following characteristics:

length	-	1.08 inch
diameter	-	0.67 inch
ogive	-	spherical
jacket thickness	-	0.063 inch
base plug length	-	0.25 inch
jacket material	-	silicone elastomeric RTV-602
filling	-	glycerin & water
weight	-	5.5 grams

Following preliminary tests, it was determined that a commercially-available marking pellet could be used to economically provide 12-gauge test data. These pellets had a thin skin composed of gelatin and glycerine and they were filled with a lead-free oil-based paint. The specific gravity of the paint was 1.2, virtually identical to that of the 60/40 glycerine/water mix used in the other liquid balls. These pellets were procured from the Nelson Paint Company, Iron Mountain, Michigan 49801. These "Nelson Marking Pellets" were fired from a 12-gauge (12ga) riot gun and from a "Nel-Spot 007" CO₂ marking pistol.

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WEAPON SYSTEM FIRING TESTS

Firing tests by the H. P. White Laboratory, Belair, MD performed under contract DAAD05-73-C-0532 yielded information on the following:

1. accuracy at ranges of 6.4, 20, 35, 50 and 70 meters
2. stress-condition accuracy at 35 meters
3. cold temperature storage and firing characteristics
4. gross effect of cross-wind
5. maximum range

Contractor reports on results of firing tests of the 3-inch diameter, 40mm, and 12-gauge Liquid Balls, are located in Appendixes C, D and E.

IMPACT TESTS

Munitions Branch, USALWL, funded physiological testing of the three Liquid Balls through Biological Sciences Branch, USALWL to AAI Corporation. Physiological testing was completed in September 1973. Refer to LWL Technical Report No. 74-79 "The Effects of Less Lethal Projectiles." This report, which is in preparation at this time, will provide information on impact damage done by various projectiles.

RESULTS & CONCLUSIONS

1. Weapon systems firing tests indicate that the accuracy characteristics of the Liquid Balls in existing launchers would permit consistent hits on a designated individual at a range no greater than about 20 meters.
2. Poor accuracy appeared to be in part due to viscous shear of the liquid filler in the larger balls. At low temperature when the filler became relatively inviscid, the accuracy improved.
3. Maximum range for employment in volley fire against crowds would be slightly over 100 meters for the 40mm and 3-inch diameter Liquid Ball systems as tested. Maximum range for the 12-gauge Liquid Ball system tested was about 65 meters.
4. The present launch system for the 3-inch diameter Liquid Ball is operationally unacceptable due to its low reloading rate. Use of a more rapidly reloadable launcher, several preloaded throwaway launchers, or use of the balls in a multiple-shot launcher (possible vehicle mounted) could overcome this problem; however its utility would still be limited by aiming and accuracy considerations.
5. The present hard nylon sabot for the 40mm Liquid Ball makes this particular configuration hazardous.
6. Impact test results available to date indicate the 3-inch Liquid Ball exhibits less hazard to test targets than the smaller sizes of balls for the same level of energy.

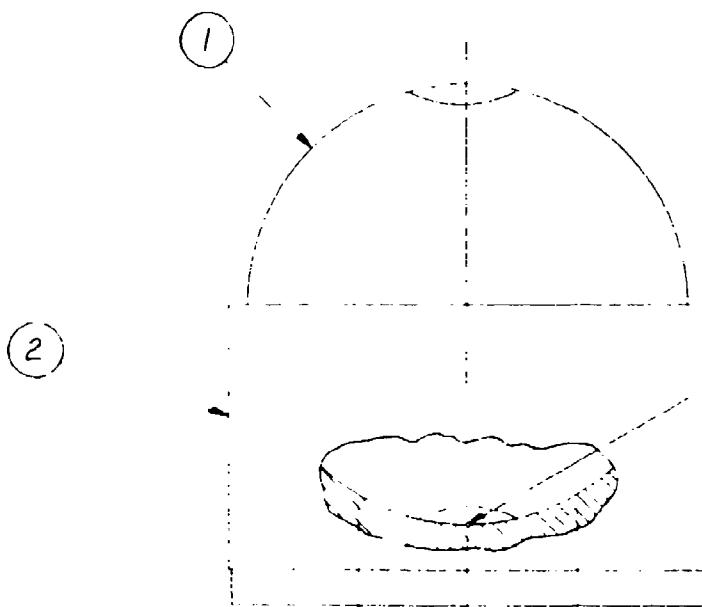
RECOMMENDATIONS

1. When additional evaluated information on damage phenomena associated with blunt trauma for the Liquid Balls and certain other items developed under Task 01-F-72 becomes available, it is recommended that the Parent Agency (ARMCOM) consider this and other data and develop a program to provide the US Army with a less lethal munition system which will maximize desired safe effects (possibly those associated with the 3-inch ball) and minimize those undesirable tactical, safety, and physical characteristics (some noted in this report) which preclude successful system use.
2. Should the parent agency determine (upon availability of this evaluated information) that a 3-inch liquid-filled sphere would present the best combination of desirable effects and minimum undesirable characteristics, it is recommended that a projectile be designed with internal ribbing to immobilize the liquid and thereby provide better accuracy.
3. Use of a softer ball material such as silicone elastomer RTV-602 (or other inert fragile elastomer having hardness of around Shore A 20) is recommended to preclude unnecessary laceration of sensitive tissue.

APPENDIX A

3-Inch Liquid Ball

(Drawings)



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NOTE 1

NOTES:

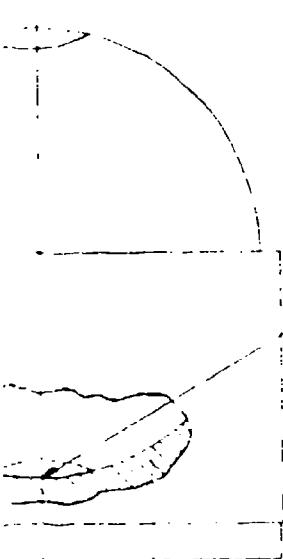
1. COAT ITEM 1 & 2 WITH RUBBER CEMENT TO DIAMETER SHOWN. ALLOW TO CURE PER MANUFACTURE'S INSTRUCTIONS. THEN ASSEMBLE, ALIGNING THE BALL'S TRADE MARK ON THE CENTER LINE AS SHOWN.
2. SUGGESTED SOURCE : BEST TEST - RUBBER CEMENT NO. 500 UNION RUBBER & ASBESTOS Co., TRENTON, N.J.

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REVISION

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(3) NOTE 1



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NOTE 1

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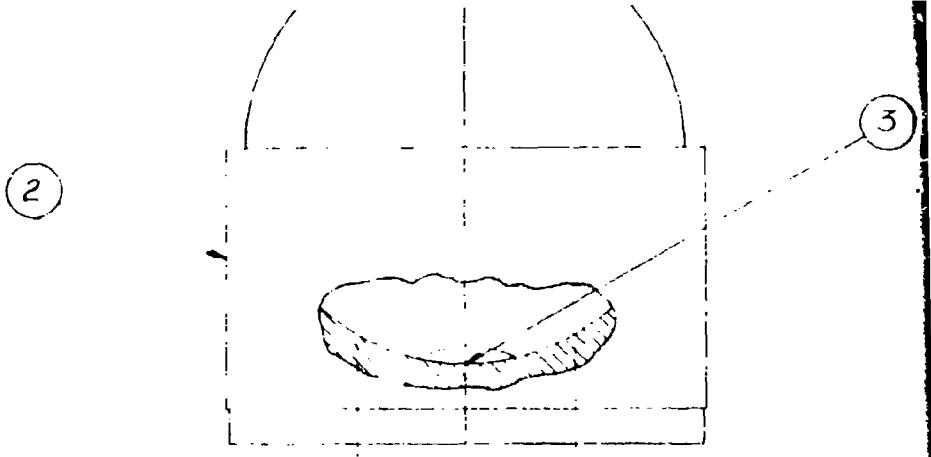
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1	04.102004	SAROT ASSEMBLY	
	-10	PROJECTILE ASSEMBLY	

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NOTE 1

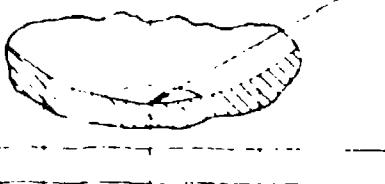
NOTES:

1. COAT ITEM 1 & 2 WITH RUBBER CEMENT TO DIAMETER SHOWN. ALLOW TO CURE PER MANUFACTURE'S INSTRUCTIONS. THEN ASSEMBLE, ALIGNING THE BALL'S TRADE MARK ON THE CENTER LINE AS SHOWN.
2. SUGGESTED SOURCE: BEST TEST-RUBBER CEMENT NO. 500 UNION RUBBER & ASBESTOS Co., TRENTON, N.J.

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Figure 1. Three-Inch Less Lethal Li

3 NOTE 1



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NOTE 1

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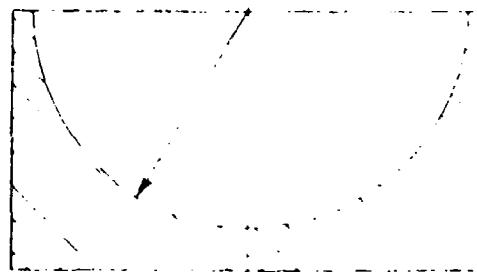
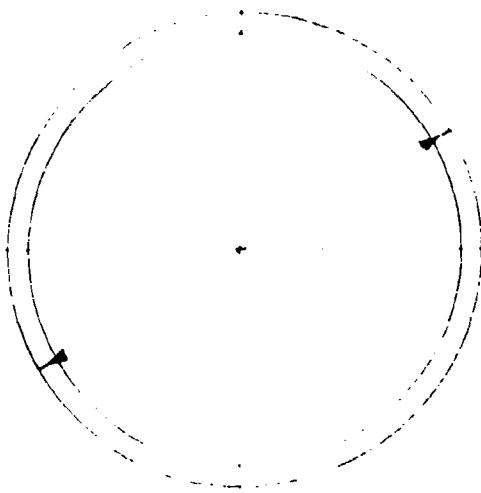
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1	04010 E004		PROJECTILE
	ASSEMBLY		
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		MATERIAL	OCTOBER 16, 1972
		FINISH	DRAFTSMAN 5A 18/10/72 10-16-72
		HEAT TREATMENT	CHECKER R. STEPHENSON 10-16-72
			PROJECT ENG R. STEPHENSON 10-16-72
			PROJECT NO 02-F-73
			APPROVED DATE
1	NEXT ASSY	USE ON	AIA CORPORATION COCKEYSVILLE, MD.
	APPLICATION		SIZE CODE IDENT NO
			C 97384
			SCALE 1/1 DRAFT

Figure 1. Three-Inch Less Lethal Liquid Ball Projectile Assembly

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ELEMENT				NOTE 2	3	
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RWISE SPECIFIED IN INCHES DECIMALS ANGLES		ORIGINAL DATE OF DRAWING		ABERDEEN PROVING GROUND, MARYLAND 21005		
		OCTOBER 16, 1972		U. S. ARMY LAND WARFARE LABORATORY		
		DRAFTSMAN	TSA 11/17/72 10-6-72			
		CHECKER	R STRICKLIN 10-16-72			
		PROJECT ENG	R STRICKLIN 10-17-72			
		PROJECT NO	02-F-73			
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AAI CORPORATION COCKEYSVILLE, MD.			C	91384		
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all Projectile Assembly



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		MATERIAL	DRAFTSMAN
		STYROFOAM - FR 1 PER	13A-116
		FED SPEC H-H-I-524 A	10-16
		TYPE 2, CLASS B	CHECKER
			R. SPANGLER
		FINISH	PROJECT ENG
			P. S. Laff
		HEAT TREATMENT	PROJECT NO.
1	040102103	040102000	02-F-73
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		APPLICATION	DA
			AAI CORPORATION
			COCKEYSVILLE, MD.

Figure 2. Sabot, 3-Inch Liquid Ball

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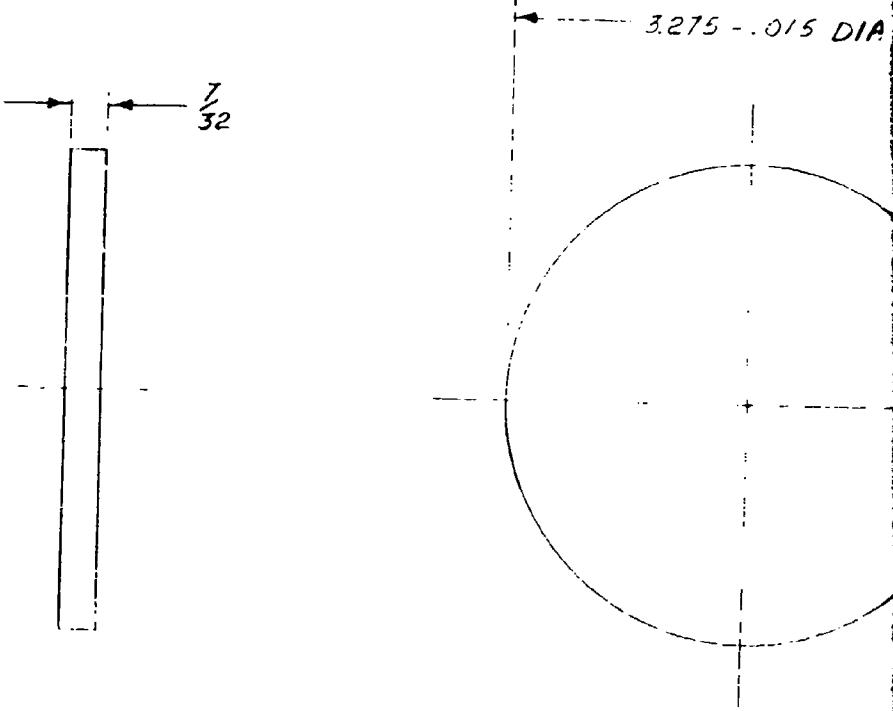
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		STYROFOAM - FR PER FED SPEC H-H-I-524 A TYPE 2, CLASS B	CHECKER R. STABILIS 10-16
		FINISH	PROJECT ENG C. D. 10-17
1	040102003 040102000		PROJECT NO 02-F-73
QTY	NEXT ASSY	USED ON	APPROVED DA
		APPLICATION	AAI CORPORATION COCKEYSVILLE, MD.
		HEAT TREATMENT	

Figure 2. Sabot, 3-Inch Liquid Ball

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FOAM - FR PER PEC H-H-I-524 A , CLASS 3		DRAFTSMAN <i>J.J. H.</i>	10-16-72	ABERDEEN PROVING GROUND, MARYLAND 21005		
		CHECKER <i>R. STAEMMLER</i>	10-16-72	U. S. ARMY LAND WARFARE LABORATORY		
		PROJECT ENG <i>P. S. L.</i>	10-17-72	SABOT		
		PROJECT NO 02-F-73				
		APPROVED	DATE	SIZE C	CODE IDENT. NO 97384	REV.
		AII CORPORATION COCKEYSVILLE, MD.		SCALE 1/1	DAAD05-72-C-0209	SHEET / OF /

Liquid Ball



NOTES:

1. MATERIAL: HOMASOTE COMP INSULATING BOARD
HOMASOTE COMPANY, TRENTON, N.J.

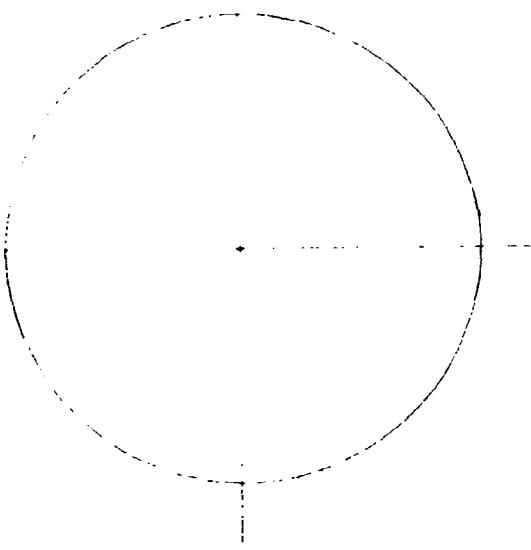
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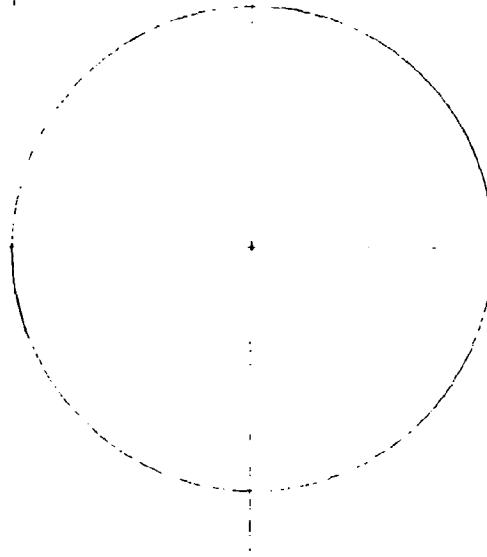
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INSULATING BOARD
TON, N.J.

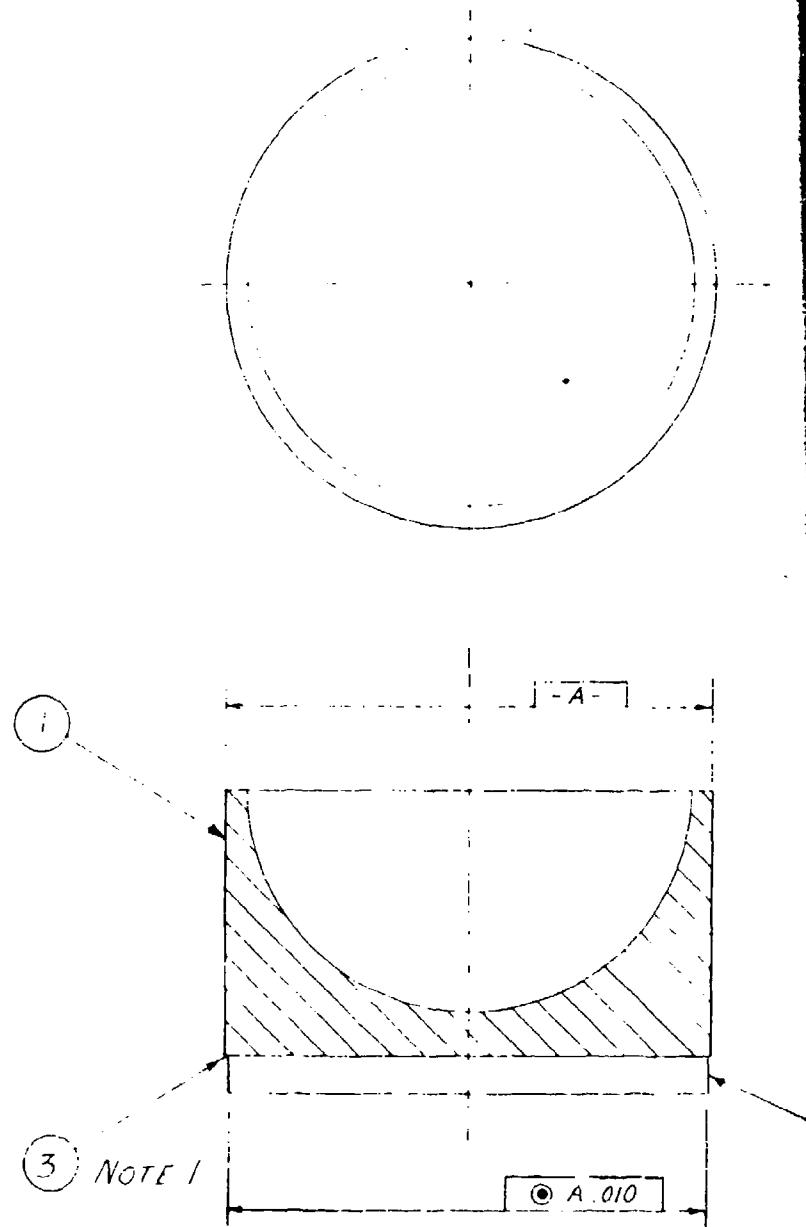
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		MATERIAL	CHECKER P. STANEKIN 10-16-72
		NOTE 1	PROJECT ENG. E. Shaff 10-17-72
			PROJECT NO. 02-F-73
1	040102003	040102000	APPROVED DATE
QTY	NEXT ASSY	USED ON	
		APPLICATION	HEAT TREATMENT:
			AAI CORPORATION COCKEYSVILLE MD.

Figure 3. Pusher, 3-Inch Liquid Ball

040102002

NAME		STOCK SIZE		MATERIAL	SPEC	ITEM
E SPECIFIED CHES MLS 10 ANGLES ±		ORIGINAL DATE OF DRAWING OCTOBER 16, 1972		[REDACTED]		
				ABERDEEN PROVING GROUND, MARYLAND 21005		
				U. S. ARMY LAND WARFARE LABORATORY		
				PUSHER		
APPROVED		DATE	SIZE	CODE IDENT. NO.	REV.	
AAI CORPORATION COCKEYSVILLE MD.			C	97384	040102002	
		SCALE 1/1	DAAD05-72-C-0209		SHEET 1 OF 1	

Ball



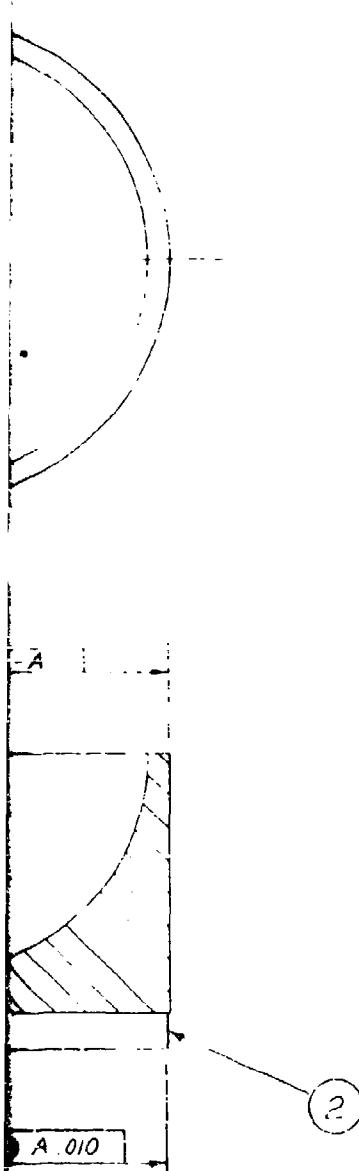
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2. SUGGESTED SOURCE: BEST TEST - RUBBER CEMENT No. 500, UNION RUBBER & ASBESTOS Co., TRENTON, N.J.

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QTY	PART NO
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1	040102001
X	
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DESCRIPTION



RUBBER CEMENT

NOTE 2

040102002

PUSHER

040102001

SABOT

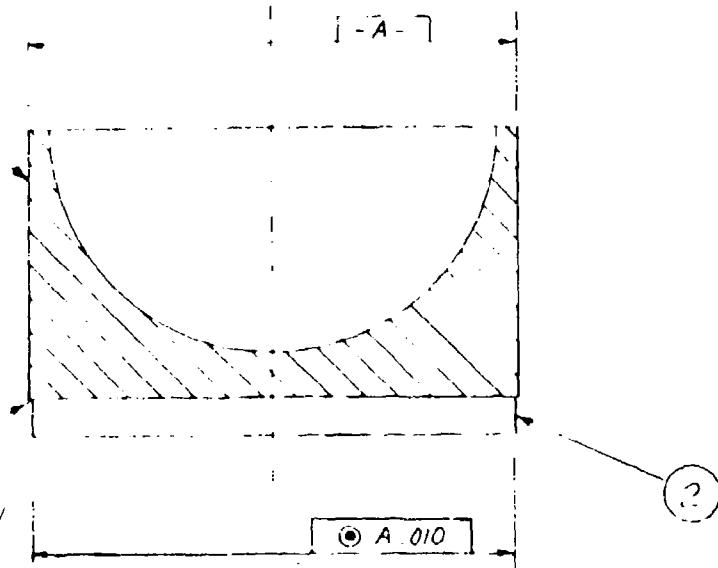
- 10 ASSEMBLY

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CEMENT		NOTE 2		3
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GLY				X
PART NAME	STOCK SIZE	MATERIAL	APEC	ITEM



CEMENT AND
MANUFACTURE'S
ASSEMBLY.

TEST - RUBBER
RUBBER & ASBESTOS

AR		RUBBER CEMENT	
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1	040102001	SABOT	
X	-10	ASSEMBLY	
		UNLESS OTHERWISE SPECIFIED	ORIGINAL DATE OF DRAWING
		DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES ± ± .010 ±	OCTOBER 16, 1972
		MATERIAL	DRAFTSMAN OSHIKI 10-16-72
			CHECKER RSPNKHUN 10-16-72
			PROJECT ENG ELLY 10-17-72
			PROJECT NO 02-F-73
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		APPLICATION	
		HEAT TREATMENT	

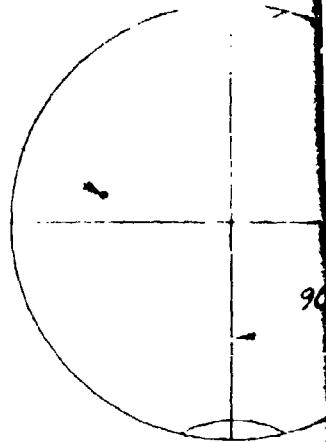
Figure 4. Sabot Assembly, 3-Inch Liquid Ba

040102003

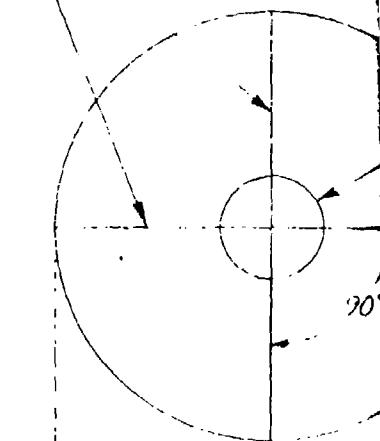
CEMENT				NOTE 2		3
						2
						1
PLY						X
PART NAME		STOCK SIZE		MATERIAL	SPEC	ITEM
OTHERWISE SPECIFIED RE IN INCHES ON DECIMALS ± .010		ORIGINAL DATE OF DRAWING OCTOBER 16, 1972		ABERDEEN PROVING GROUND, MARYLAND 21005 U. S. ARMY LAND WARFARE LABORATORY SABOT ASSEMBLY		
		DRAFTSMAN R. S. HUNTER	10-16-72			
		CHECKER R. S. HUNTER	10-16-72			
		PROJECT ENG R. S. HUNTER	10-17-72			
		PROJECT NO 02-F-73				
APPROVED		DATE	SIZE	CODE IDENT. NO 97384	040102003	REV.
HAT CORPORATION COCKEYSVILLE, MD.			SCALE 1/1	DAAD05-72-C-0209	SHEET 1 OF 1	

In Liquid Ball

FILL HOLE
NOTE 3



SCORE MARKS



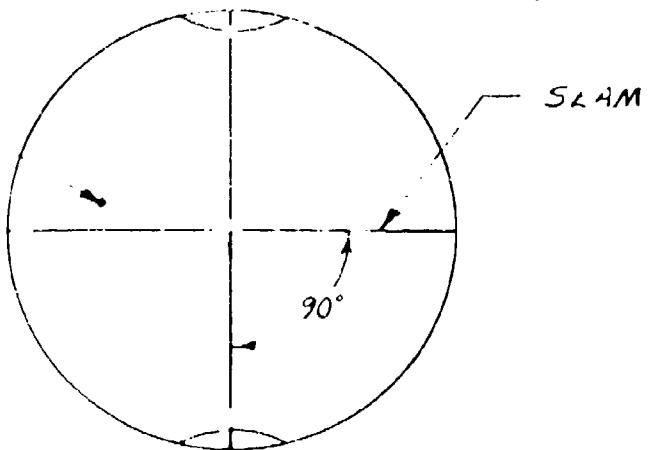
NOTES:

1. MAKE FROM P/N 10003417. SUGGESTED SOURCE, THE NATIONAL LATEX PRODUCTS CO. 246 EAST 4TH STREET, ASHLAND, OHIO. 44805.
2. SCORE DEPTH TO BE .025.
3. FILL BALL WITH LIQUID CONSISTING OF:
COMMERCIAL GLYCERIN (60% BY WT)
WATER (40% BY WT)
ADJUST WEIGHT OF FILLED BALL TO
 265.0 ± 3.0 GRAMS TOTAL, THEN HEAT SEAL.
4. FILLED BALL MUST WITHSTAND A
3 FOOT DROP TEST ON HARD CONCRETE
WITHOUT RUPERTURING. (POINT OF IMPACT
TO BE AT INTERSECTION OF SCORE MARKS.)

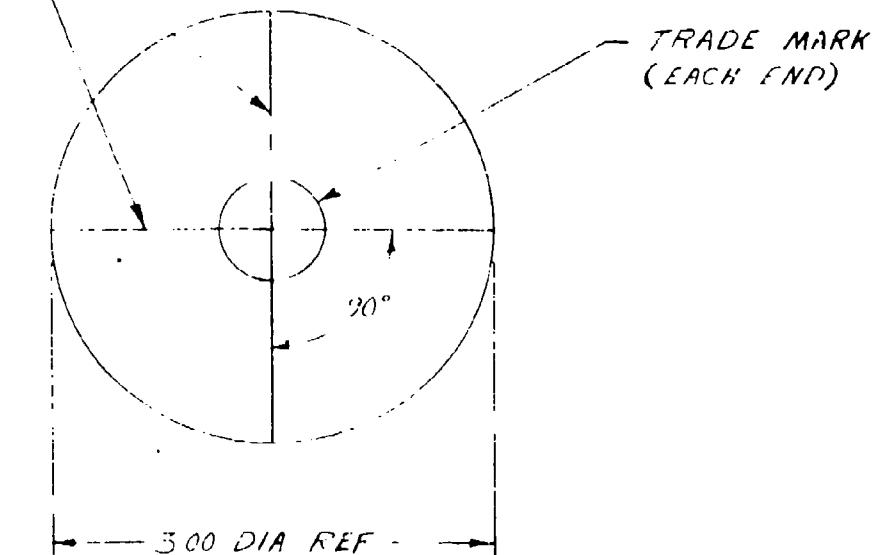
— 300 DIA REF —

QTY	

FILL HOLE
NOTE 3



SCORE MARKS AROUND CIRCUMFERENCE



SUGGESTED
ATEX PRODUCTS
EET, ASHLAND.

025.

CONSISTING OF:
(60% BY WT)
(40% BY WT)

D BALL TO

, THEN HEAT SEAL.

STAND .1

YARD CONCRETE
POINT OF IMPACT
(OF SCORE MARKS)

QTY	PART NO	PART NAME

REVISIONS

LETTER	DESCRIPTION	DATE	APPROVED

IM

REFERENCE

TRADE MARK
EACH (END)

040102002

PART NAME	STOCK SIZE	MATERIAL	SPEC	ITEM
OTHERWISE SPECIFIED	ORIGINAL PAGE			

REVISION IS

LTR	DESCRIPTION	DATE	APPROVED

M

ERENCE

TRADE MARK
(EACH END)

01/02/004

PART NAME

STOCK SIZE

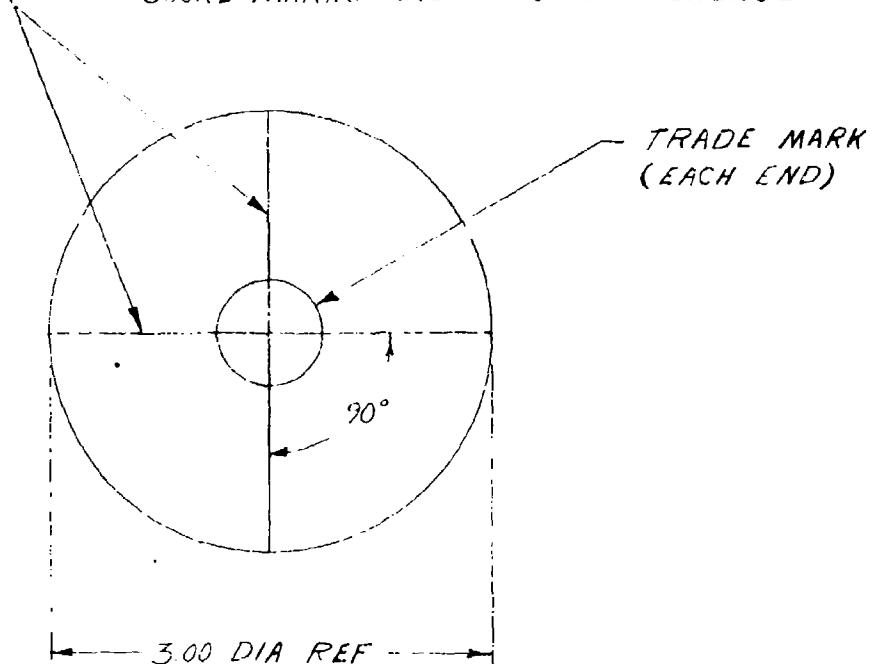
MATERIAL

SPEC

ITEM

OTHERWISE SPECIFIED ORIGINAL DATE
OF DRAWING

SCORE MARKS AROUND CIRCUMFERENCE



SUGGESTED
ATEX PRODUCTS
ET, ASHLAND.

925.
CONSISTING OF:
(60% BY WT)
(40% BY WT)
BALL TO
THEN HEAT SEAL.
STAND A
RD CONCRETE
POINT OF IMPACT
(SCORE MARKS.)

QTY	PART NO.	PART NAME	
		UNLESS OTHERWISE SPECIFIED	ORIGINAL DATE OF DRAWING
		DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES	OCTOBER 16, 1971
		= = = = 15°	
		MATERIAL:	DRAFTSMAN J.S. SHIFFMAN 10-1
		NOTE 1	CHECKER R. STAERKIN 10-1
			PROJECT ENG. E. Shiffman 10-1
			PROJECT NO. 02-F-73
1	040102000	FINISH: _____	APPROVED
QTY	NEXT ASSY	USED ON	
		HEAT TREATMENT: _____	AAR CORPORATION
			COCKEYSVILLE, MD.
		APPLICATION	

Figure 5. Projectile, 3-Inch Liquid Ball

REFERENCE

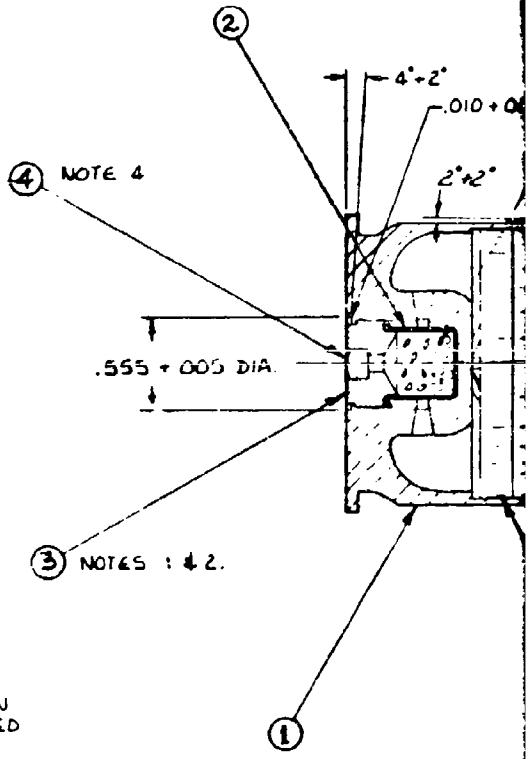
TRADE MARK
(EACH ENL)

040102004

PART NAME	STOCK SIZE			MATERIAL	SPEC	ITEM
OTHERWISE SPECIFIED	ORIGINAL DATE OF DRAWING					
IONS ARE IN INCHES INCS ON NS DECIMALS ANGLES = = = = 15°	OCTOBER 16, 1972			ABERDEEN PROVING GROUND, MARYLAND 21005		
TE 1	DRAFTSMAN	'SA 11111	10-16-72	U. S. ARMY LAND WARFARE LABORATORY PROJECTILE		
	CHECKER	R STACKLIN	10-16-72			
	PROJECT ENG	R Schaff	10-17-72			
	PROJECT NO.	02-F-73				
	APPROVED	DATE	SIZE	CODE IDENT. NO.	REV.	
ATTMENT:	AAI CORPORATION COCKEYSVILLE, MD.		C	97384	040102004	
		SCALE 1/1	DAAD05-72-C-0209		SHEET 1 OF 1	

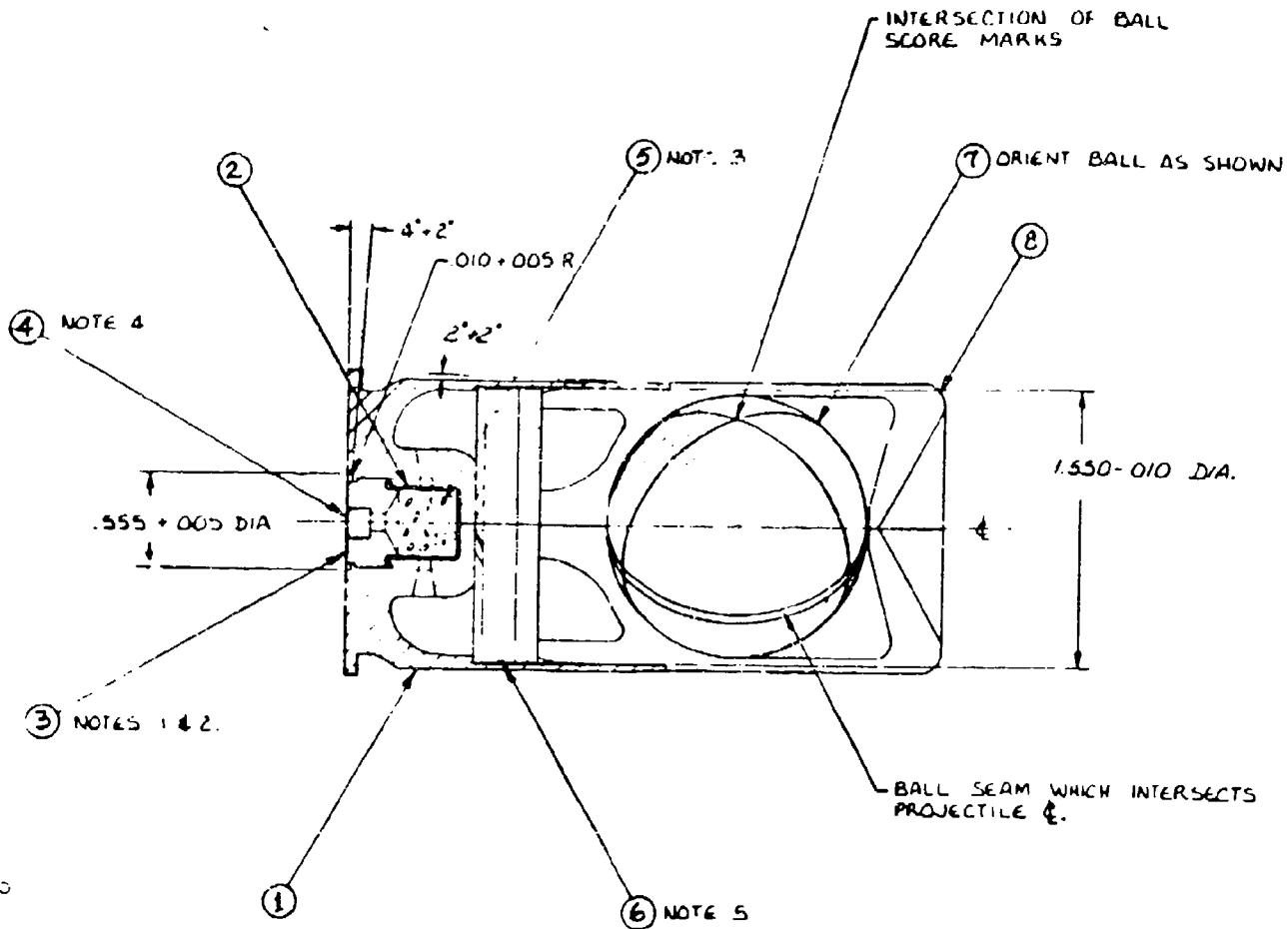
Inch Liquid Ball

APPENDIX B
Some Liquid-Bath
(Drawings)



NOTES:

- 1- BASE PLUG TO BE FLUSH TO .005 MAX. BELOW REAR OF CASE. ADVISORY- DEAD LOAD REQUIRED 7000 LB. MIN.
- 2- CRIMP BASE PLUG 360° AVERAGE UNSEATING FORCE TO BE 3500 LBS. OR MORE WITH NO VALUES BELOW 2000 LBS. CRIMP FORCE 11000 TO 13000 LBS. USING A CRIMPING PUNCH .555 + 005 OUTSIDE DIA AND 4° + 2° FAIR ANGLE.
- 3- LOAD WITH M9 PROPELLANT TO MEET THE MEAN VELOCITY OF 245 FEET PER SECOND. (2.2 GRAINS ±.01 GRAINS)
- 4- PRIMER TO BE FLUSH TO .003 MAX. BELOW BASE PLUG.
- 5- OBSTURATOR INSERTION TO BE ACCOMPLISHED BY TEMPORARILY DEFORMING A POINT ON THE OBSTRUCTING SURFACE WHICH PROVIDES A VENT TO PREVENT PROPELLANT CUP DEFORMATION.



Mr. B. E. GRI
L. M. - R. C. D.

LEAVING FORCE
LA JES
= TO 13000 LBS
CS OUTSIDE DIA

THE MEAN
· (22 CRAINS)

BELOW BASE PLUG.
LISHED BY
THE SATURATING
PREVENT

4	540103004	ABOT	
1	040103003	— ASSEMBLY	
1	040103002	CALCULATOR	
NOTE 3		PERMANENT	
1	87493925	COVER, M42	M
1	F8446.1	FLUG, BASE	M
1	B814612	CUP, WHEEL CHARGE	
1	040103001	CASE 45MM (MODIFIED)	
1	040103000-10	ASSEMBLY	
BTY	PART NO	PART NAME	
		UNLESS OTHERWISE SPECIFIED	ORIGINAL DATE OF DRAWING
		DIMENS-SIZE IN INCHES	
		PROJECTION IN FEET	
		POSITIONS	
		DETAILED	ANGLES
		—	—
		MATERIAL	
		—	
		FINISH	
		—	
		TEMP TREATMENT	
BTY	RESTD BY	USED ON	
APPLICATION		—	
DAI CORP COCKEYS			

Figure 1. 40mm Less Lethal Liquid Ball Projectile Assembly

REVISIONS			
REV.	DATE	SATV	APPROVED

- IDENTIFICATION OF BULL SCRE MARKS

NOTE 3

→ GREAT BULL AS SHOWN

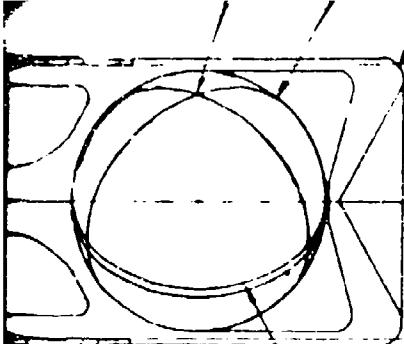
3

153-210 24.

- line segment which intersects
triangle.

卷之二

040105000



1530-010 DIA.

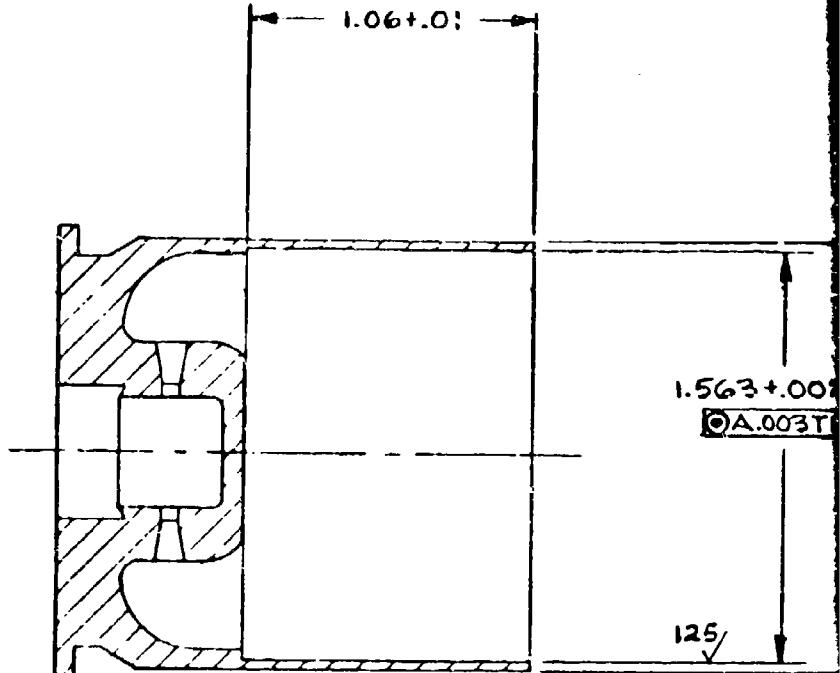
BALL SEAM WHICH INTERSECTS
PROJECTILE #.

⑥ NOTE 5

ITEM	REF. NO.	CASE NAME	STOCK NO.
	4 040103004	ABOT	
	1 040103003	ASSEMBLY	
	1 040103002	CHANGER	
NOTE 3		CHASSIS	
	1 8733325	CH-ER. M42	M3 LOT NO. 8820
	1 FP44-01	FLUID BASE	M42-C1
	1 PH44-02	UP. LIQUID CHARGE	
	1 040103001	CASE 45MM (SACLIFIED)	
	1 040103000-10	ASSEMBLY	
QTY	REF. NO.	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES PROJECTION OF REFS. TO DRAWING APPROVAL NO.	ON DATE OF OR DRAWING DRAFTSPR. DRAFTSPR. NO. CHECKER CHECKER NO. PROJECT NO. PROJECT NO. PROJECT NO. PROJECT NO.
			8-31-73
			DRAFTER: DRAFTSPR.: CHECKER: CHECKER NO.: PROJECT NO.: PROJECT NO.: PROJECT NO.: PROJECT NO.
- FINAL -		FINISH	APPROVED
QTY	REF. NO.	HEAT TREATMENT	DATE
		AAI CORPORATION COCKEYSVILLE, MD	AAI CORP IDENT NO. D 97384 040103000
		APPLICATION	SCALE DAADDS-72-C-0203 SHEET 1 OF 1

040103000

hal Liquid Ball Projectile Assembly



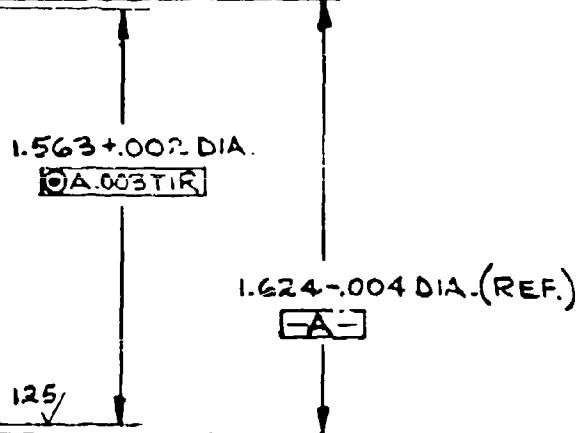
NOTES:

1. MODIFY STANDARD 40 MM : M118
CARTRIDGE CASE.
ORDNANCE PART NUMBER 8844610.

Figure 2. Cartridge Case, 40mm Liquid Ball

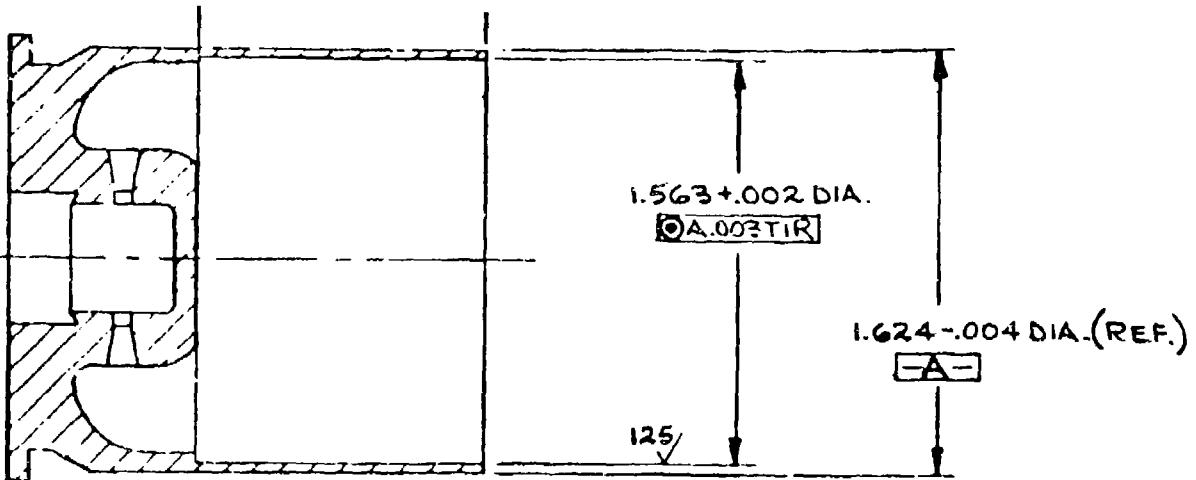
REVIS ONS

LTR	DESCRIPTION	DATE	APPROVED



040103001

ID	FAINT NAME	STOCK SIZE	MATERIAL	SPEC	ITEM
	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES	ORIGINAL DATE OF DRAWING	U. S. ARMY LAND WARFARE LABORATORY ABERDEEN PROVING GROUND MARYLAND 21005		
		8-31-73			
	MATERIAL	DRAFTSMAN			
	SEE NOTE 1	Lowe			
	CHECKER	8/21/73			
	PROJECT ENG	8/23/73			
	PROOFREAD				
			CASE, CARTRIDGE 40MM: M118,		



M118
8844610.

QTY	PART NO	PART NAME	STOCK SIZE
		UNLESS OTHERWISE SPECIFIED	U.S. ARMY LAN ABERDEEN PROVE
		DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES	CASE, C 40MM: MODIFI
		MATERIAL SEE NOTE 1	8-31-73
		FINISH	DRAFTSMAN J.M. Gland 8/15/73
1	040105000	—	CHECKER LOWE 8/21/73
QTY	NEXT ASSY	USED ON	PROJECT ENG Sibley 8/23/73
		APPLICATION	PROJECT NO 02-F-73
		HEAT TREATMENT	APPROVED DATE
			AAI CORPORATION COCKEYSVILLE, MD.
			SIZE CODE IDENT NO C 97384
			SCALE 2/1 DAAD

Figure 2. Cartridge Case, 40mm Liquid Ball (Modified M118)

563+.002 DIA.

2A.003 TIR

1.624-.004 DIA. (REF.)

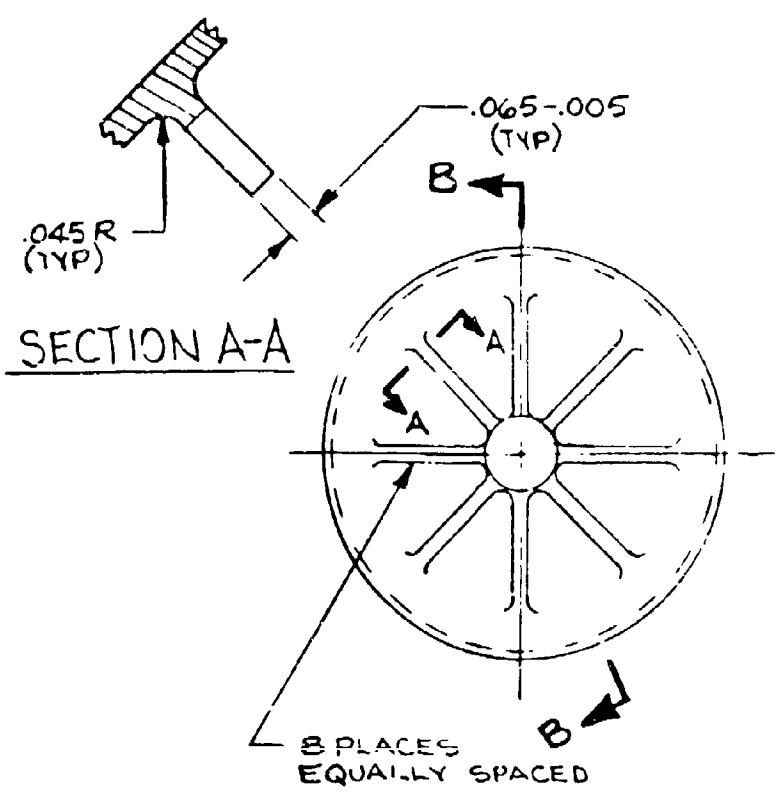
-A-

6/

040103001

PART NAME	STOCK SIZE	MATERIAL	SPEC	ITEM	
OTHERWISE SPECIFIED DIMENS IN INCHES DECIMALS IS DECIMALS ANGLES	ORIGINAL DATE OF DRAWING 8-31-73	U. S. ARMY LAND WARFARE LABORATORY ABERDEEN PROVING GROUND MARYLAND 21005			
NOTE 1	DRA-TSMAN CHECKER PROJECT ENG PROJECT NO	8/15/73 8/21/73 8/23/73	CASE, CARTRIDGE 40 MM: M118, MODIFIED		
	APPROVED	DATE	SIZE	COJE IDENT NO	REV
	AAI CORPORATION COCKEYSVILLE, MD.		C 97384	040103001	
			SCALE 2/1	DAAD05-72-C-0209	SHEET 1 OF 1

Grid Ball (Modified M118)



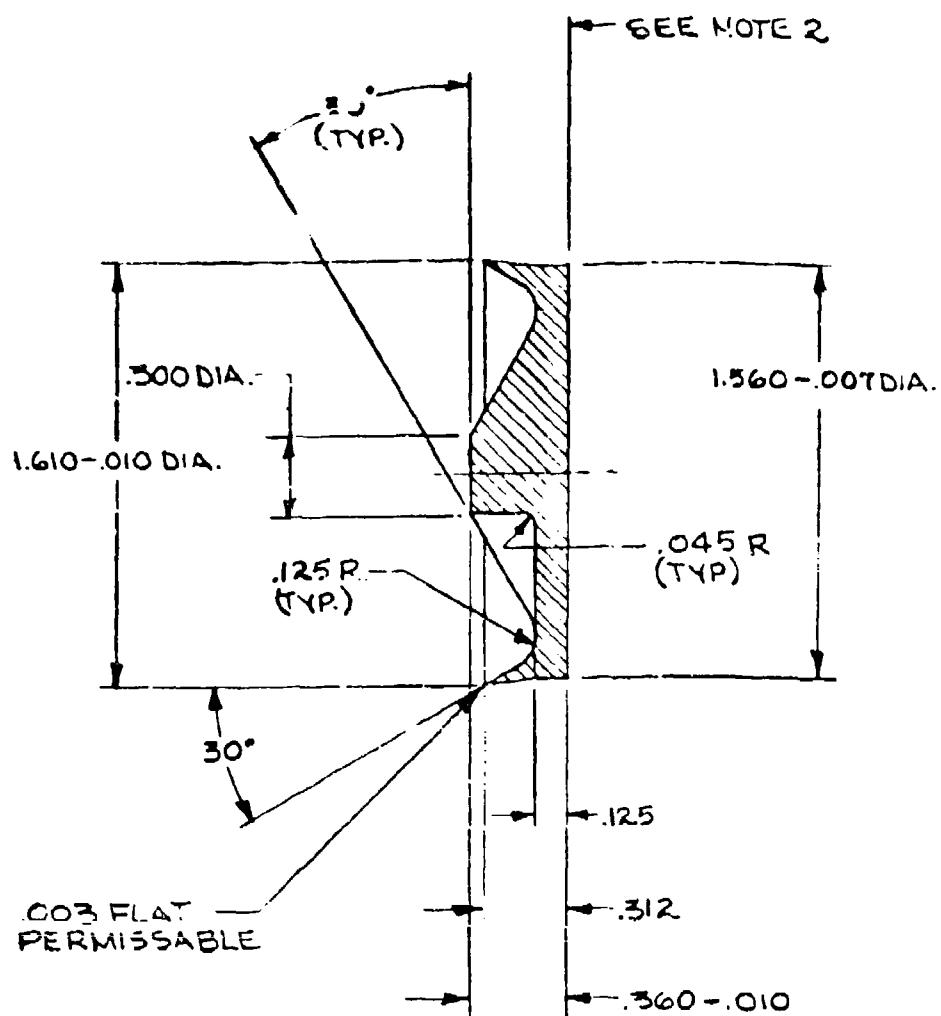
A technical drawing of a mechanical part, likely a flange or base plate. The part has a central vertical column with a top horizontal slot. The width of this slot is labeled as .300 DIA. The total height of the central column is .300 DIA. A side view shows a thickness of .125 R (TYP.) and a bottom edge angle of 30°. The bottom surface is labeled .003 FLAT PERMISSABLE.

NOTES:

1. CORNER AND FILLET RADII .005 MAX.
UNLESS OTHERWISE NOTED
2. THIS SURFACE TO BE FLAT WITHIN .005
AND FREE FROM FLASH AND EJECTION
PIN MARKS.

QTY	PART NO	UNLES
		DIMEN
		TOLE
		FRAC
		T -
		MATERI
		PLA
		HIT
		POU
		FINISH
1	040103000	—
QTY	NEXT ASSY	USED ON
APPLICATION		

05



SECTION B-B

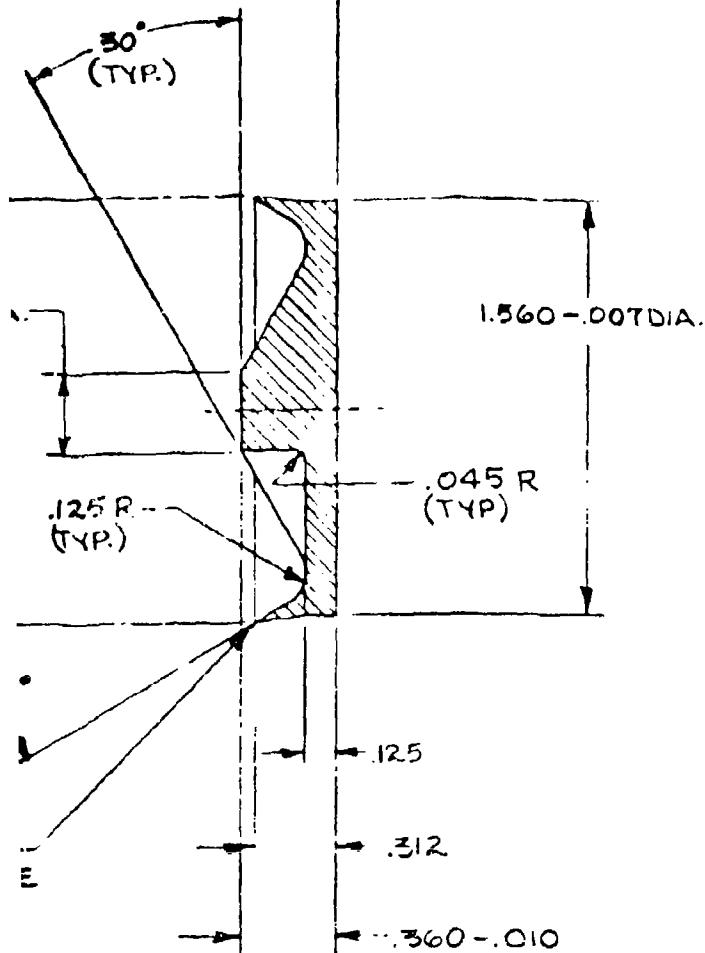
15 MAX.

1 THIN .005
EJECTION

QTY	PART NO	PART NAME	STOCK SIZE
		UNLESS OTHERWISE SPECIFIED	
		DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES — ± .010 ± 1°	
		MATERIAL	
		PLASTIC HI-DENSITY POLYETHYLENE	
		FINISH	
1	040103000	APPROVED	DATE
QTY	NEXT ASSY	HEAT TREATMENT	SIZE
	USED ON		CODE IDENT. NO.
	APPLICATION		C 9738
			SCALE 2/1

Figure 3. Obturator, 40mm Liquid Ball

SEE NOTE 2

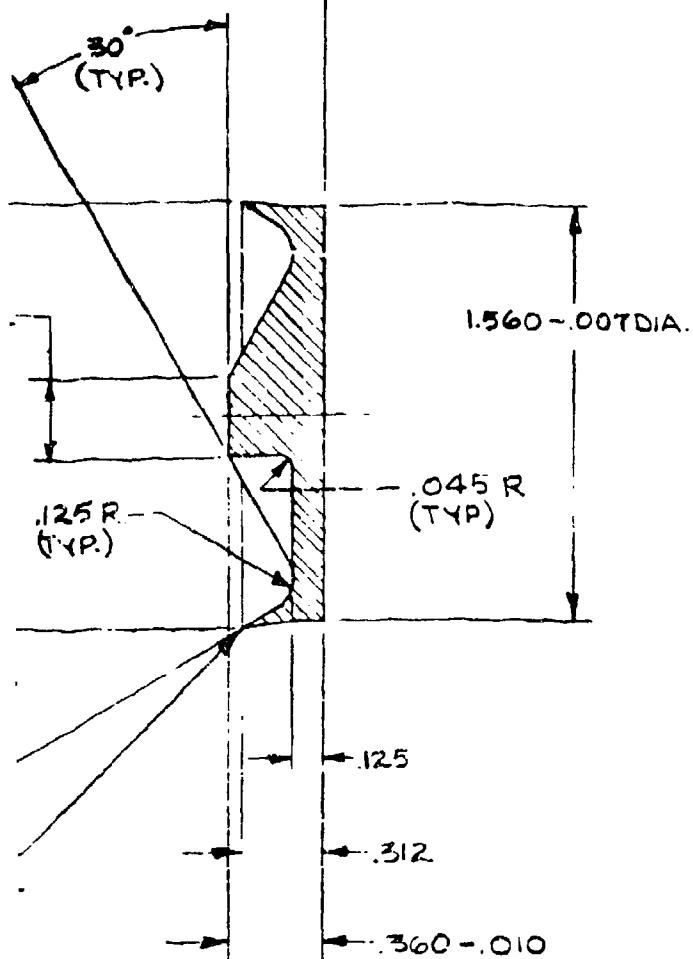


SECTION B-B

040103002

PART NAME	STOCK SIZE	MATERIAL	SPEC	ITEM
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES ± .010 ± .010 ± 1°	ORIGINAL DATE OF DRAWING 8-31-73	ABERDEEN PROVING GROUND, MARYLAND 21005		
MATERIAL PLASTIC HI-DENSITY POLYETHYLENE	DRAFTSMAN CHECKER PROJECT ENG PROJECT NO 12-372 8/22/73 8/22/73 02-F-73	U. S. ARMY LAND WARFARE LABORATORY OBTURATOR		
FINISH	APPROVED	DATE	SIZE	CODE IDENT. NO
HEAT TREATMENT	AAI CORPORATION COCKEYSVILLE, MD		C	97384 040103002
		SCALE 2/1	DAAD05-72-L-0209	REV.
			SHEET 1 OF 1	

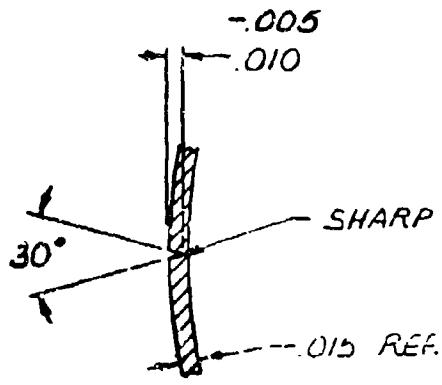
SEE NOTE 2



SECTION B-B

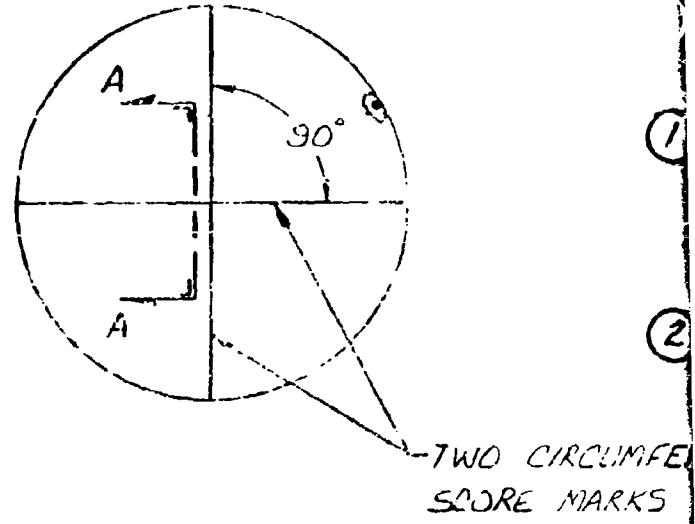
040103002

PART NAME UNLESS OTHERWISE SPECIFIED	STOCK SIZE	MATERIAL	SPEC	ITEM
DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES = ± .010	ORIGINAL DATE OF DRAWING 8-31-73	ABERDEEN PROVING GROUND, MARYLAND 21005 U. S. ARMY LAND WARFARE LABORATORY OBTURATOR		
MATERIAL PLASTIC HI-DENSITY POLYETHYLENE.	DRAFTSMAN KIRK 12-3-72 CHECKER LOWE 8/22/73 PROJECT ENG SUBJ 8/22/73 PROJECT NO 02-F-73			RKV.
FINISH —	APPROVED AAI CORPORATION COCKEYSVILLE, MD	DATE	SIZE CODE IDENT. NO. C 97384 040103002	
HEAT TREATMENT —		SCALE 2/1	DAAD05-72-C-0209	SHEET 1 OF 1



SECTION A-A

SCALE 10 $\frac{1}{2}$
(TYP. BALL SCORE
MARK)



NOTES:

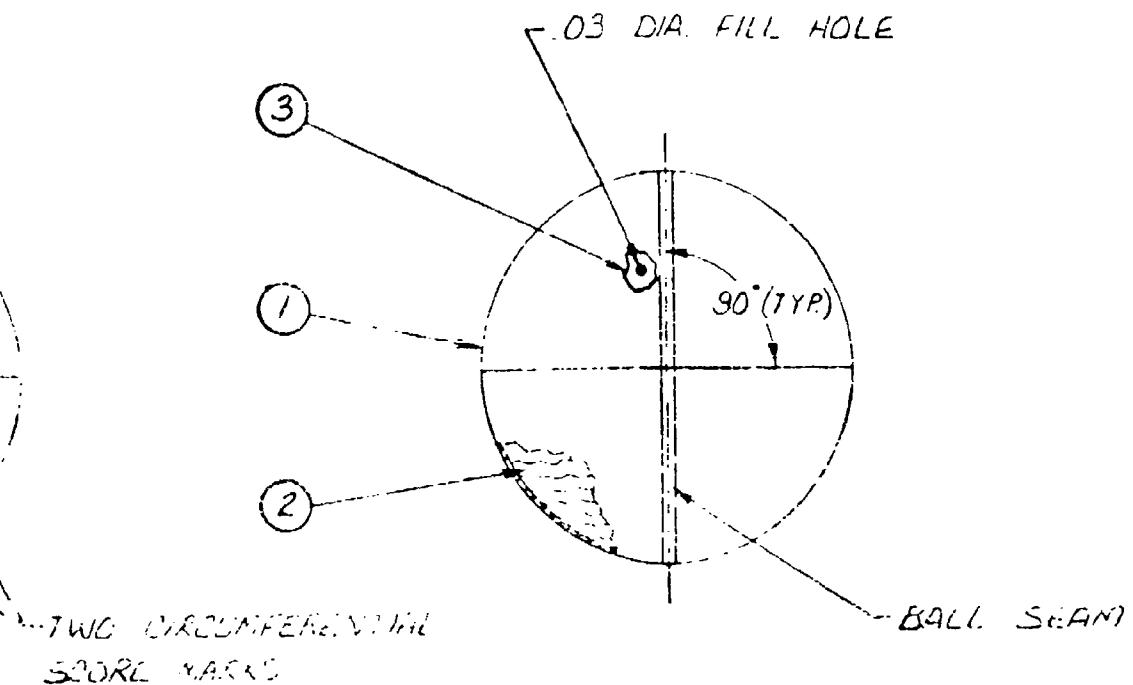
- 1-BALL MUST BE - HALEX (3 STAR)
TABLE TENNIS BALL (MADE IN
SINGAPORE)
- 2-LIQUID TO BE A MIXTURE OF
60% GLYCERIN AND 40%
WATER BY WEIGHT.
- 3-SEAL WITH DUCO® CEMENT
E.I. DU PONT DE NEMOURS & CO. (INC.)
WILMINGTON, DEL. 19898
OR EQUIVALENT.
- 4-FILL BALL COMPLETELY WITH A
HYPODERMIC NEEDLE AND SYRINGE OR
EQUIVALENT. AFTER FILLING, CLEAN
SURFACE AROUND HOLE THOROUGHLY
WITH WATER AND LET AIR DRY.
SEAL FILL HOLE WITH MINIMUM AMOUNT
OF SEALANT AND LET AIR DRY PER
MANUFACTURERS INSTRUCTIONS.

AR.	SE	LN
AR.		
1	-1	BA
X	-10	BI
QTY	PART NO	
		UNL
		DIME
		TOL
		FRAC
		=
		MATER

REVIS ONS

LTR

DESLR PTION

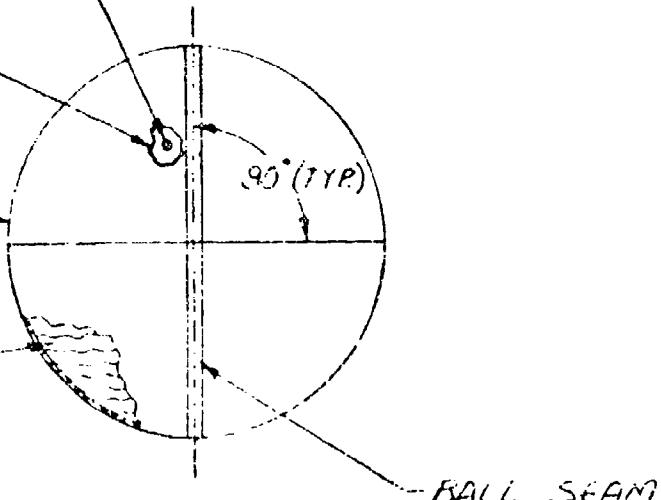


AR.		SEALANT	NOTE 3	
AR.		LIQUID	NOTE 2	
1	-1	BALL	NOTE 1	
-10 BALL ASSEMBLY				
OR	PART NO.	PART NAME	STICK SIZE	MATERIAL
UNLESS OTHERWISE SPECIFIED			DRAWING	
DIMENSIONS ARE IN INCHES				
FRACTIONS DEIMALS ANGLES				
WT			8-31-73	U S ARMY LAND WARFARE
				ABERDEEN PROVING GROUND MA

REVIS ONS

ITR	DESCRIPTION	DATE	APPROVED

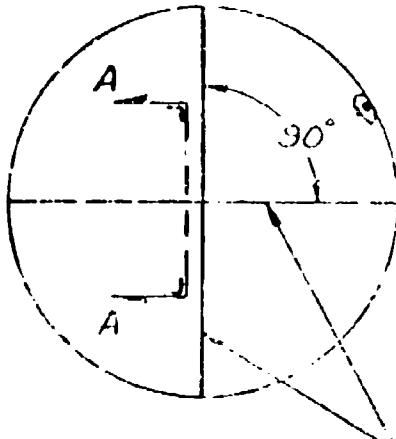
.03 DIA. FILL HOLE



040103003

ALANT	NOTE 3				3
LIQUID	NOTE 2				2
ALI	NOTE 1				1
ALL ASSEMBLY					
PART NAME:		STOCK SIZE	MATERIAL	SPEC	ITEM
LESS OTHERWISE SPECIFIED		FINAL DATE			
DIMENSIONS ARE IN INCHES		DRAWING			
EXCEPTS IN					
INCHES					
DECMAL					
.01		8-31-73	U. S. ARMY LAND WARFARE LABORATORY		
5°			ABERDEEN PROVING GROUND, MARYLAND 21005		
PARTSMAN		LOWE 8/2/73			
CHECKER		R. M. T. 8/2/73			
NOTE 1					

MARK)



(1)

(2)

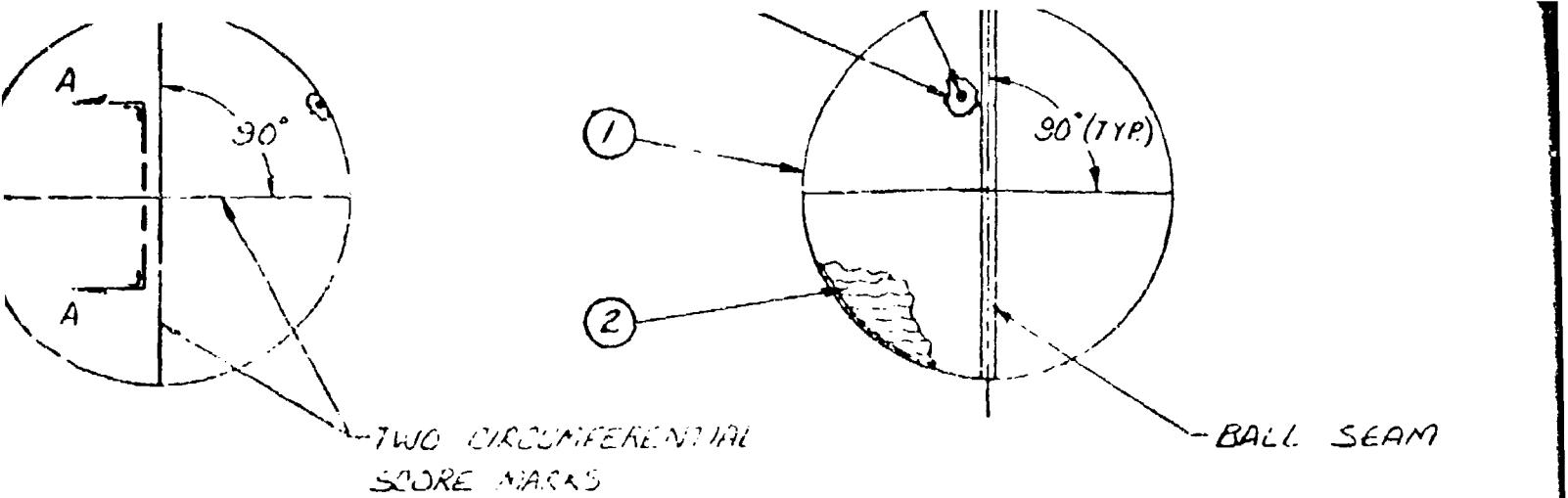
TWO CIRCUMFERE
SCORE MARKS

NOTES:

- 1-BALL MUST BE-HALF (3 STAR)
TABLE TENNIS BALL (MADE IN
ENGLAND)
- 2-LIQUID TO BE A MIXTURE OF
60% GLYCERIN AND 40%
WATER BY WEIGHT.
- 3-SEAL WITH DUCO® CEMENT
E.I. DU PONT DE NEMOURS & CO. (INC.)
WILMINGTON, DEL. 19898
OR EQUIVALENT.
- 4-FILL BALL COMPLETELY WITH A
HYPODERMIC NEEDLE AND SYRINGE OR
EQUIVALENT. AFTER FILLING, CLEAN
SURFACE AROUND HOLE THOROUGHLY
WITH WATER AND LET AIR DRY.
SEAL FILL HOLE WITH MINIMUM AMOUNT
OF SEALANT AND LET AIR DRY PER
MANUFACTURERS INSTRUCTIONS.

AR.	SEA
AR.	LID
1	BAL
X	-10 BAL
ST	PART NO
	UNLESS
	IMPOSED
	STANDARD
	PRACTIC
	MATERIAL
	N
	FINISH
1	040103000
011	NEXT ASSY
	USE ON
	APPL CATION
	HEAT TREAT

Figure 4. ball Assembly.



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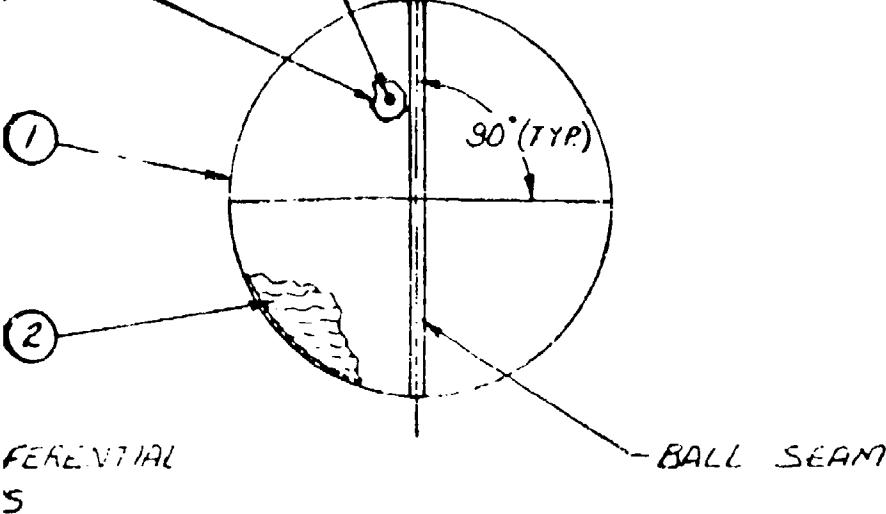
CO (INC.)

TH A
SYRINGE OR
CLEAN
ROUGHLY
RY.
JM AMOUNT
DRY PER
VS.

AR.		SEALANT	NOTE 3
AR.		LIQUID	NOTE 2
1	-1	BALL	NOTE 1
X	-10	BALL ASSEMBLY	
SP	PART NO	PART NAME	STOCK SIZE
		UNLESS OTHERWISE SPECIFIED	
		ITEM ISSUE NUMBER	
		REVISIONS	
		01	5°
		MATERIAL	
		NOTE 1	
		FINISH	
1	020103000		
QTY	RECLASST	USG'D ON	DATE RECEIVED
APPL CATN			
		APPROVED	DATE
		AAI CORPORATION	CODE IDENT
		COCKEYSVILLE, MD.	NO
		C 97384 04	SCALE 2/1 DAAD05-

BALL A

FIGURE 5. Ball Assembly, 40mm Liquid Ball

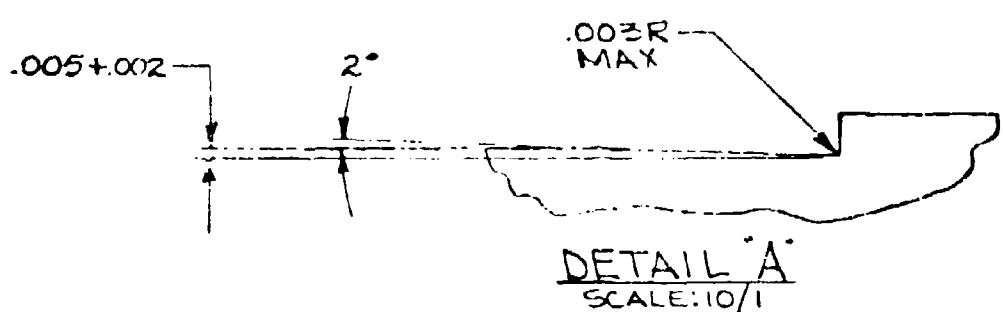
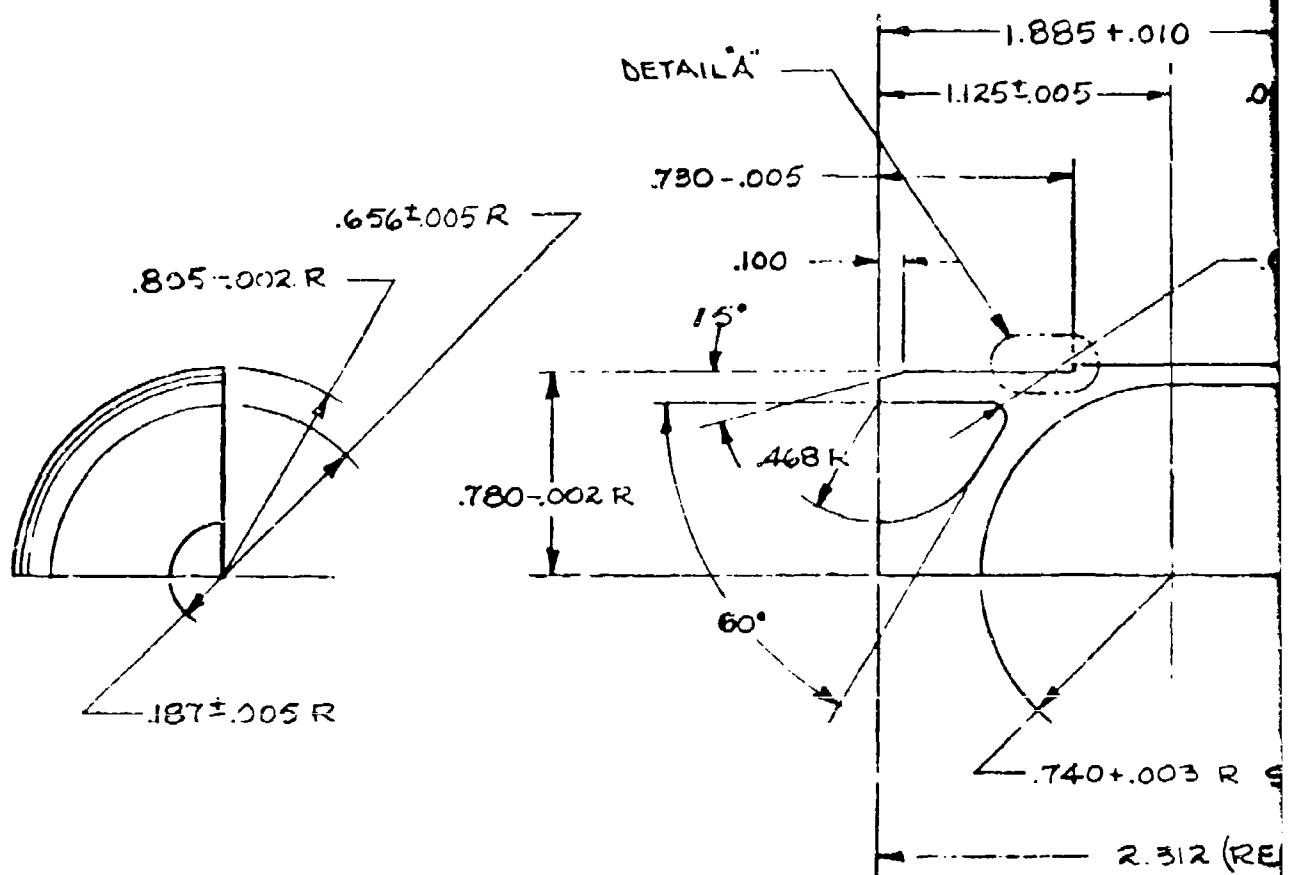


FERENTIAL
S

040103003

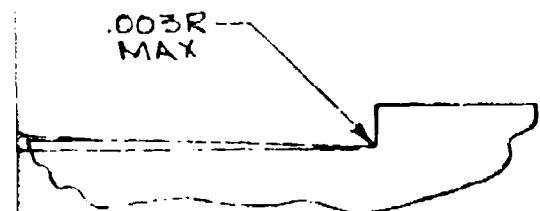
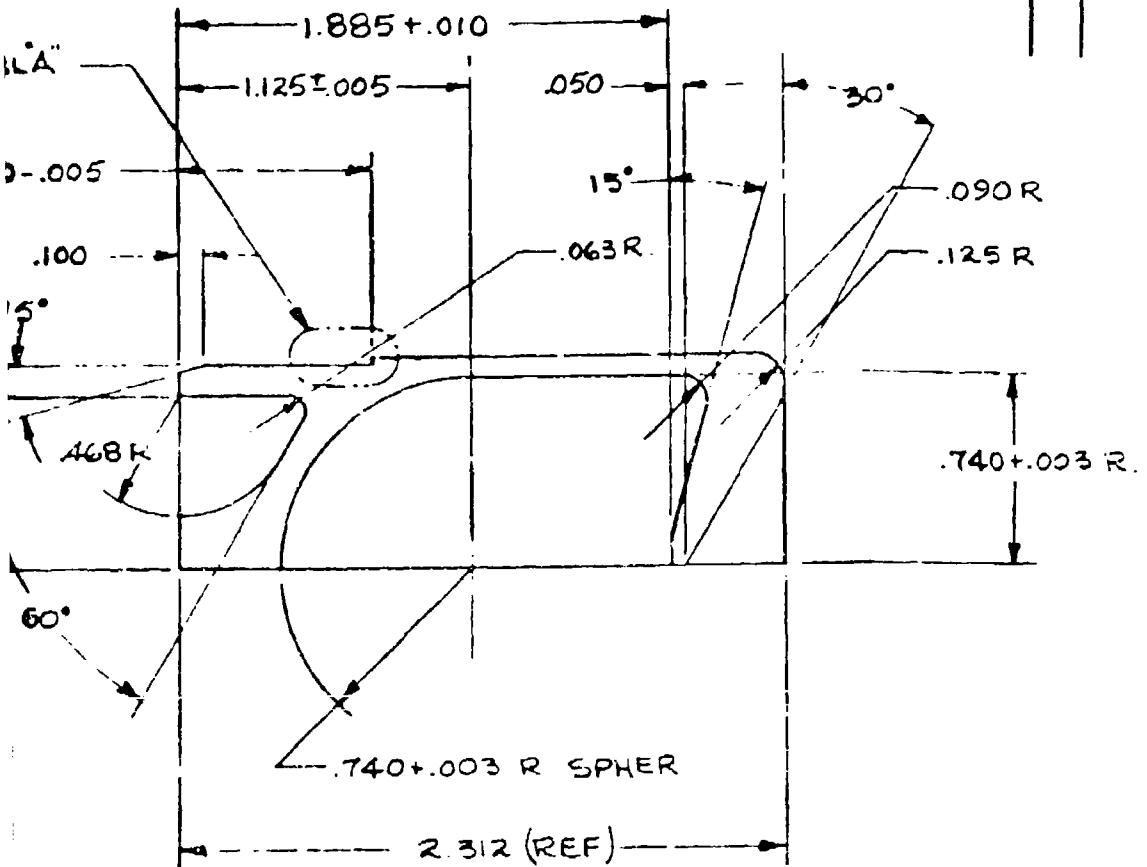
SEALANT	NOTE 3				3
LIQUID	NOTE 2				2
BALL	NOTE 1				1
BALL ASSEMBLY					
PART NAME UNLESS OTHERWISE SPECIFIED	STOCK SIZE	MATERIAL	SPEC	ITEM	
DIAMETER IN INCHES FRACTIONAL OR DECIMAL	8-31-73	U S ARMY LAND WARFARE LABORATORY ABERDEEN PROVING GROUND MARYLAND 21005			
MATERIAL NOTE :	LOWE 8-21-73 CHECKER	PROJECT END 8-23-73 PROJECT INC 02-F-73			
FINISH	APPROVED	DATE	RECORDED BY	REV	
HEAT TREATMENT	C 97384 040103003				
AAI CORPORATION C. SKYESVILLE, MD.					
SCALE 2/1 DAAD05-72-C-0209 SHEET 1 OF 1					

Assembly, After Liquid Ball



QTY	PART NO	UNLESS
		DIMENSION
		TOLERANCE
		FRACTION
		=
		MATERIAL

REVISIONS	
LTR	DESCRIPTION

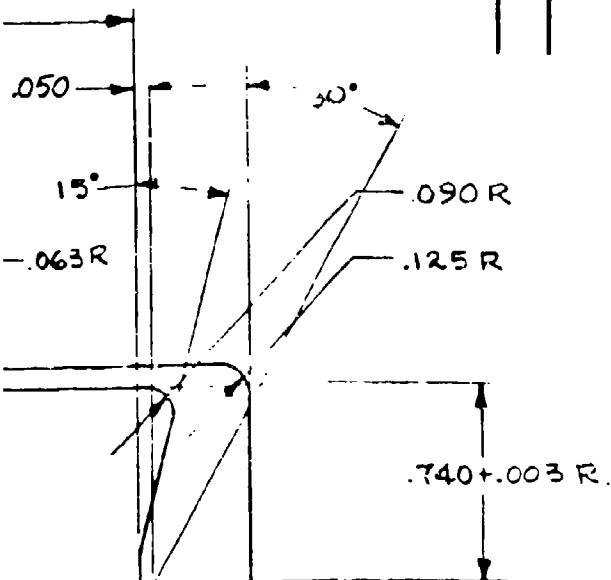


DETAIL A
SCALE: 10/1

QTY	PART NO	PART NAME	STOCK SIZE	MATERIAL
		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES ± .010 1° MATERIAL	SIGNAL DATE FOR DRAWING 8-31-73 DRAFTSMAN 12-3-72 REVIEWED APPROVED	ABERDEEN PROVING GROUND. U. S. ARMY LAND WARFARE

REVIS ONS

LN#	DESCRIPTION	DATE	APPROVED



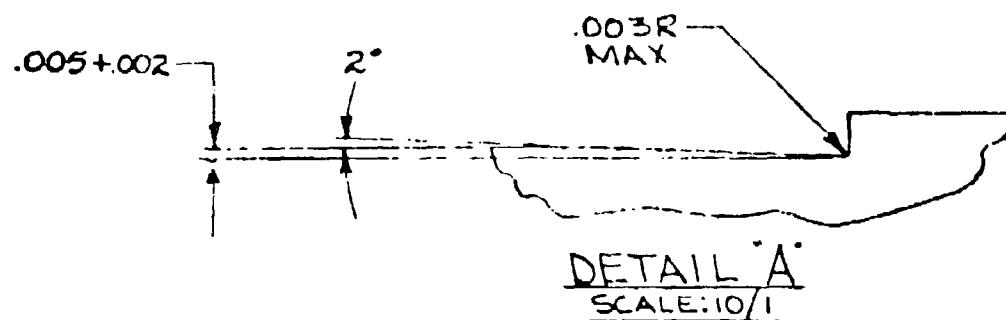
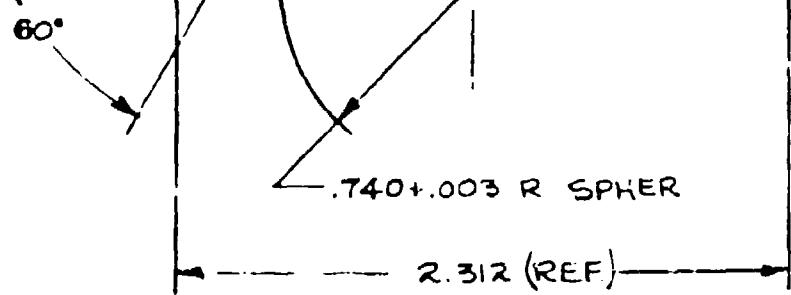
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REF) ---

040103004

PART NAME LESS OTHERWISE SPECIFIED	STOCK SIZE	MATERIAL	SPEC	ITEM
DIMENSIONS ARE IN INCHES DEGREES ON ANGLES	RIGID DATE DRAWING	██████████	██████████	██████████
DECIMALS .010	8-31-73	██████████	██████████	██████████
ANGLE 1°	DRAFTER	12-3-72	██████████	██████████
REVIS ONS	██████████	██████████	██████████	██████████
U.S. ARMY LAND WARFARE LABORATORY	██████████	██████████	██████████	██████████

.005 R



QTY	PART NO	PART NAME	ORIGINAL DATE OF DRAWING
UNLESS OTHERWISE SPECIFIED			
		DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES	
		$\pm .010$	$\pm 1^\circ$
		MATERIAL	DRAFTSMAN
		NYLON FOAM 15% FIBERGLAS FIBERFIL F3-15 NYLAFILE FOAM	CHECKER
			PROJECT ENG
			PROJECT NO.
4	040103D00	FINISH	8-31-7
QTY	NEXT ASSY	USED CN	APPROVED
APPLICATION		HEAT TREATMENT	AAC CORPORATION COCKEYSVILLE, MD

Figure 5. Sabot Segment, 40mm Liquid Ball

R SPHER

(REF) --

040103004

PART NAME		STOCK SIZE		MATERIAL	SPEC	ITEM
LESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DEGREES IN DECIMALS ANGLES .10		ORIGINAL DATE OF DRAWING 8-31-73		ABERDEEN PROVING GROUNDS MARYLAND 21005 U.S. ARMY LAND WARFARE LABORATORY SABOT SEGMENT		
LON FOAM FIBERGLAS SERFIL F3-15 LAFILE FOAM		CRAFTSMAN T. ALLEN	12-3-72			
		CHECKER LOWE	8/22/73			
		PROJECT ENG J. SCHWARTZ	8/23/73			
		PROJECT NO 02-F-73				
APPROVED		DATE	SIZE	CODE IDENT NO C 97384	040103004	REV.
TREATMENT		AAI CORPORATION COCKEYSVILLE, MD.		SCALE 2/1	DAADGS-72-C-0209 SHEET 1 OF 1	

E, 40mm Liquid Ball

APPENDIX C

3-Inch Liquid Ball

(Test Firing)

TEST REPORT
LISS LETHAL 3-INCH LIQUID BALL - I

(Task 02-F-73, Contract
No. DAAD05-73-C-0552
Work Order No. 11)

Prepared For
United States Army
Land Warfare Laboratory
Aberdeen Proving Ground, Maryland

By
H.P. White Laboratory
Bel Air, Maryland 21014

January 1974

c. 3

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ABSTRACT

This report presents the results of tests on less-lethal 3-inch Liquid Ball munitions in accordance with the provisions of Contract No. DAAD05-75-C-0552, Task 02-I-73 (an agreement between the U.S. Army, Land Warfare Laboratory and H.P. White Laboratory).

ABSTRACT

This report presents the results of tests of less lethal 3-Inch Liquid Ball munitions in accordance with the provisions of Contract No. DAAD05-75-C-0552, Task 02-1-75 (an agreement between the U.S. Army, Land Warfare Laboratory and H.P. White Laboratory).

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SECTION I. SCOPE OF WORK

1. OBJECTIVE

The objective of these tests was to provide the external ballistic data necessary to assess the ballistic performance of the 3-Inch Liquid Ball less lethal ammunition.

2. MATERIALS

The following materials were used in the conduct of this test program:

- a) 3-Inch Liquid Ball less lethal projectiles (see Figure 1).
- b) Blank Propelling cartridges (Model C200) (see Appendix D and Figure 1).
- c) M1200 12 Gauge riot gun (Serial No. 1571489).
- d) Launcher, Model L-110.
- e) Miscellaneous range and photographic equipment (see Appendix E).

3. SCOPE OF TESTS

Twenty-four (24) rounds of 3-Inch Liquid Ball ammunition were fired on an instrumented indoor range to determine velocity, accuracy, muzzle exit phenomena, relative impact characteristics and the effect of shooter stress on accuracy. Ten (10) rounds were fired on an outdoor range to determine maximum range and maximum effective hitting range when the projectiles are subjected to environmental variables such as wind. Three (3) rounds were fired to determine the effect of cold temperature firing. (see Table 1)

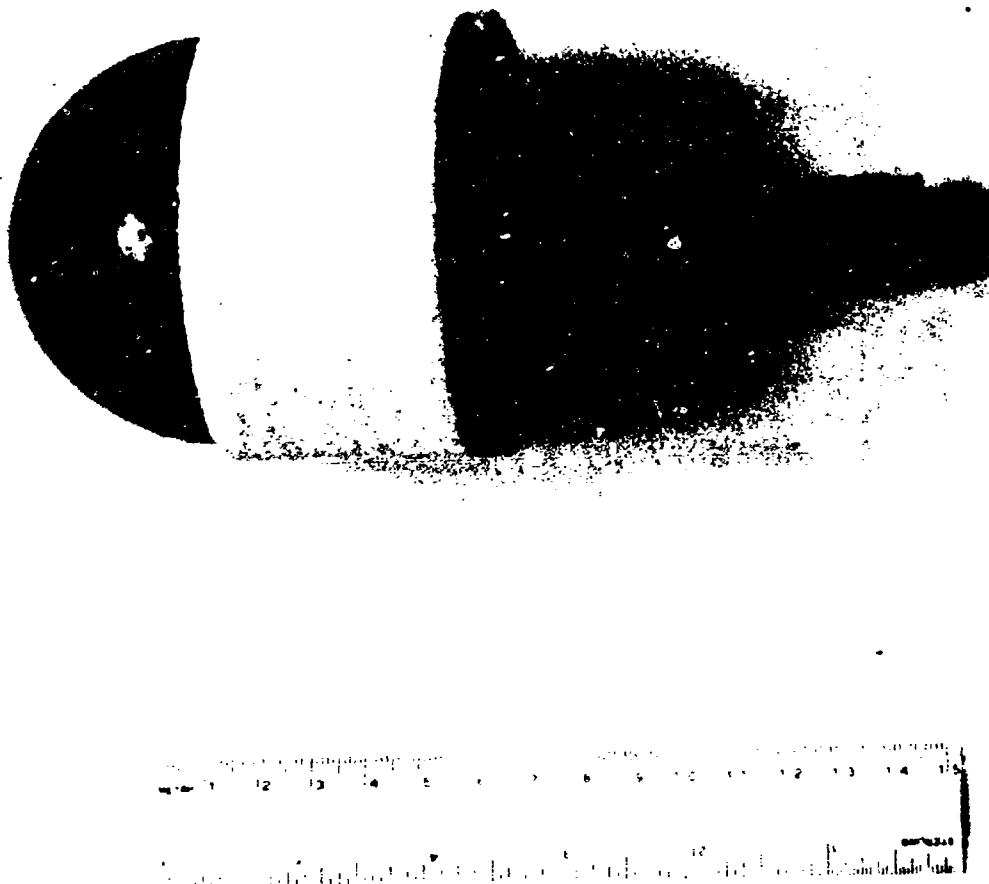


Figure 1. 3-Inch Liquid Ball and Model C-200 Blank Propelling Cartridge.

TABLE I. SOURCE OF TESTS

Round No.	Velocity Str-1c 2m	Energy Str-1c 5m	Velocity Nozzles 2m	Energy Nozzles 5m	Impact Coordinates Impact Coordinates	Mozzie Exit Phenomena	Impact Phenomena & Indentation	Gold Test	Maximum Range	Maximum Effective Hit- ting Range	Shooter Stress
1-14	1.8	C	C	C	A	A	A	A	A	A	T,A
15	HS	C	C	C	A	A	A	A	A	A	A
20-27	HS	C	C	C	A	A	A	A	A	A	A
28-42					A	A	A	A	A	A	A
43-45					A	A	A	A	A	A	A
46-48					A	A	A	A	A	A	A
49-55					A	A	A	A	A	A	A

HS - High Speed Motion Picture

LS - Lumline Screens/Time Interval Counter

Micro Flash

C - Calculated
C - Measured

Measured Time

Lined - Estimated

SECTION II. PROCEDURE

1. VELOCITY

- a) The velocity of twenty-four (24) rounds of the 3-Inch Liquid Ball projectiles was derived from data collected by erecting lumiline screens 5.06, 8.06, 14.9 and 17.9 feet (1.54, 2.46, 4.54, and 5.46 meters respectively) from the muzzle of an M1200 riot gun (with launcher attachment) fired from the prone/rest position. The outputs of these screens activated time interval counters from which the velocities at 2 and 5 meters from the muzzle were calculated.
- b, Velocity of two (2) of the 3-Inch Liquid Ball projectiles was calculated from data extracted from high speed motion pictures of the muzzle and initial few feet of projectile flight recorded by 16mm Fastax motion picture cameras positioned 4 feet 8 inches to the right of the line of fire and 9 inches in front of the muzzle. The film speed, used to compute the projectile velocity, was determined from timing marks on the film created by a time pulse generator.

2. PROJECTILE ENERGY

Projectile energy of the 3-Inch Liquid Ball projectile was calculated by applying the unfired projectile weight and the velocity data derived per 1, above, to the standard energy formula--

$$\text{Kinetic Energy} = (1/2) MV^2$$

3. ACCURACY

The accuracy of the 3-Inch Liquid Ball ammunition was determined from impact data on a target constructed of 2" x 4" wood backing, 1/2-inch thick Homasote and faced with paper. The accuracy of the ammunition was determined by measuring the horizontal and vertical dispersion from the aiming point on the target. Standard deviations in the x and y directions and the mean radius were calculated.

4. IMPACT CHARACTERISTICS

Indentations in the Homasote, produced by each projectile impact, were measured using a depth micrometer and the average indentation was calculated. Indications of projectile attitude at impact were observed and noted. These data were collected from the target when positioned 6.4, 20, 35, and 50 meters from the muzzle of the prone/rest fired M1200 riot gun and launcher.

5. EFFECT OF SHOOTER STRESS ON ACCURACY

Three (3) shooters fired five (5) rounds each at an anthropometric silhouette target positioned 35 meters from the shooter. In order to induce stress, each shooter was told that he would have an average of 4 seconds (varying from 3 seconds to 5 seconds) to shoulder the M1200, sight and fire at the target. This timing was accomplished by utilizing a cardboard shield which obscured the shooter's view of the target before and after each shot. No warning was given before the shield was raised and the time interval started. The coordinates of each shot in relation to the center of the chest area of the silhouette were recorded. Whether or not a hit had been scored on the man-size silhouette was recorded and any hits in critical areas (groin and eyes) were noted. Standard deviation of the x and y coordinates and the mean radius were calculated from these data.

6. MAXIMUM RANGE

The M1200, with its barrel elevated 30° from horizontal, was fired from a bench rest on a 400-meter outdoor range. After each shot, the distance the projectile traveled before its initial impact with the ground was measured as well as the deflection right or left of the line of sight.

7. MAXIMUM EFFECTIVE HITTING RANGE

The launcher equipped M1200 was bench rest fired at an anthropometric silhouette target positioned 35 meters from the muzzle. After four (4) firings without scoring a hit on the silhouette, the target was moved to 20 meters from the muzzle for the remaining 3 firings. Wind velocity at each firing was measured using a Dwyer "Wind Meter." Silhouette target hits and misses, impact coordinates, and flight time from muzzle to target (timed by stop watch) were recorded. Estimate of maximum effective hitting range was the average of three (3) observers opinion of range at which tactical hits could be expected under test conditions.

8. COLD TEMPERATURE FIRING

Three (3) of the 5-Inch Liquid Ball and three (3) power charges were stored at -45°F for 24 hours. They were then stored for one additional hour at 0° immediately before being fired from the machine rest mounted M1200 riot gun and launcher. Each shot was remotely fired. The fired cartridge case, M1200, and launcher were examined for damage after each shot. Impact coordinates and the indentation in the "Homasote" faced target were measured and recorded.

9. MUZZLE EXIT PHENOMENA

Three (3) 3-Inch Liquid Ball projectiles were photographed as they exited the muzzle of the launcher. Two (2) rounds were photographed using two (2) 16mm Fastax High Speed Motion Picture cameras simultaneously. One Fastax camera was positioned perpendicular to and 4 feet 8 inches from the line of fire, 9 inches forward of the muzzle. The other Fastax camera was positioned 38.3 feet forward of the muzzle, 3 feet to the left of the line of fire and focused on the muzzle. Both cameras ran at a nominal 4000 frames per second. The third round was photographed using a Linhof 4" x 5" camera positioned 4 feet to the right and 1 foot in front of the muzzle. Four (4) General Radio "Stroboslave" recycling flash units were pulsed at .0015 second intervals for a flash duration of .000003 seconds each. These strobes provided four (4) exposures of the projectile within 17 inches of the muzzle. Projectile muzzle exit was studied by examining the 16mm high speed motion picture film and enlargements of the 4" x 5" microflash photography (see Figure 2).

10. SAFETY

In addition to normal safety procedures followed during firing, personnel were required to wear respiratory protection during conduct of the test to preclude inhalation of any small droplets of the glycerin and water mix in the projectile which might have been aerosolized upon target impact.

SECTION III. RESULTS

1. VELOCITY

Table II is a summary of the velocity data contained on the data sheets of Appendix A.

TABLE II. RESULTS OF VELOCITY TESTS (f.p.s.)
3-INCH LIQUID BALL

	Muzzle** (2 rds)	2m* (21 rds)	5m* (21 rds)
Maximum	116.0	145.8	143.6
Minimum	108.0	110.7	93.2
Average	112.0	129.8	125.6

*Lumiline screens/time interval counter
(accuracy \pm 3 f.p.s.)
**High Speed Motion Pictures
(accuracy \pm 20 f.p.s.)

2. PROJECTILE ENERGY

Table III is a summary of calculations based on the data contained in Appendix A.

TABLE III. PROJECTILE ENERGY (ft-lbs)
3-INCH LIQUID BALL

	Muzzle (2 rds)	2m (21 rds)	5m (21 rds)
Maximum	127.2	200.9	194.9
Minimum	110.5	115.9	82.1
Average	118.8	160.3	150.7

3. ACCURACY

Table IV is a summary of calculations based on the data contained in Appendix A.

TABLE IV. RESULTS OF ACCURACY TESTS
3-INCH LIQUID BALL.

Target Distance (meters)	Group Center (from point of aim) (in.)		Extreme Spread (in.)		Standard Deviation (in.)		Mean Radius (in.)
	x	y	x	y	x	y	
6.4	-0.2	-1.5	3.8	12.1	27.0	24.3	3.0
20	-8.1	-62.0	27.0	24.3	9.9	8.6	11.1
35	Trajectory would not permit hits on 8'x8' target.						

4. IMPACT CHARACTERISTICS

Table V is a summary of calculations based on the data contained in Appendix A.

TABLE V. INDENTATIONS OF HOMASOTE
3-INCH LIQUID BALL.

Target Distance (meters)	Average Indentation (in.)	Minimum Indentation (in.)	Maximum Indentation (in.)
6.4	.014	0	.039
20	0	0	0
35	Trajectory would not permit hits on 8'x8' target.		

5. EFFECT OF SHOOTER STRESS ON ACCURACY

Table VI is a summary of the calculations based on the data contained in Appendix A.

NOTE: The elevation required of the M1200 in conjunction with the large diameter of the launcher attachment obscured the target from the shooter. Therefore, all subsequent firing at ranges of 20 meters or more were conducted by using a point of aim well above the target.

TABLE VI. SUMMARY OF STRESS TEST RESULTS
5-INCH LIQUID BALL, TARGET 35 METERS

Shooter	Group Center (from point of aim) (in.)		Extreme Spread (in.)		Standard Deviation (in.)		Mean Radius (in.)	Total Hits on Silhouette	Hits in Critical Area
	x	y	x	y	x	y			
A	-9.8	-45.4	34.4	5.8	15.0	2.4	9.6	0	0
B	+2.5	-24.0	50.0	90.1	20.5	41.6	54.8	1	0
C	+28.3	-47.0	70.8	30.0	28.5	12.9	24.2	0	0

6. MAXIMUM RANGE

Table VII is a summary of the data contained in Appendix A.

TABLE VII. MAXIMUM RANGE
5-INCH LIQUID BALL

	Distance (meters)	Deflection (meters)
Maximum	117.5	10-right
Minimum	91.0	2-left
Average	105.5	6.7-right

7. MAXIMUM EFFECTIVE HITTING RANGE

Table VIII is a summary of the data contained in appendix A.

TABLE VIII. MAXIMUM EFFECTIVE HITTING RANGE
3-INCH LIQUID BALL

Impact Coordinates (in.)			Wind Velocity (m.p.h.)	Average Flight Time (sec.)	Remarks
x	y	Hits			
TARGET DISTANCE 35 METERS (4 ROUNDS)					
+14.6*	-46.9*	0	9.0-10.5	0.9*	3 of 4 projectiles impacted ground at 30-31 meters.
TARGET DISTANCE 20 METERS (3 ROUNDS)					
0	-45.9**	2	10.0-11.0	0.5**	1 projectile impacted ground at 18.5 meters.

*One round only.

**Two rounds only.

It was the opinion of the three (3) observers that the maximum range at which tactical hits on a man could be expected was approximately 20 meters.

8. COLD TEMPERATURE FIRING

The launcher equipped M1200 was machine mounted and aimed at a point 100 inches above the floor at 35 meters from the muzzle. All three (3) rounds impacted the floor before reaching the target at 35 meters. No abnormalities were observed regarding the launcher, M1200 Riot Gun, or the fired cartridge cases.

Projectile filler (60% glycerin, 40% water) appeared to be in a solid state at impact. Dispersal characteristics appeared to be approximately 33% smaller than those of projectiles at room temperature. Due to the poor accuracy at 35 meters, no appreciable difference could be detected between the projectiles at room temperature and those at reduced temperatures.

9. MUZZLE EXIT PHENOMENA

The muzzle exit of three (3) rounds was recorded photographically--two (2) with 16mm high speed motion pictures and one (1) with recycling microflash. Analysis of the high speed motion pictures revealed:

- a) The projectile of Round No. 26 assumed a 9° yaw attitude immediately after clearing the muzzle.
- b) The projectile of Round No. 27 was distorted throughout the field of view of the camera (approximately 18 inches of linear travel).
- c) The velocities of the projectiles from Round Nos. 26 and 27 were 116.0 and 108.0 feet per second, respectively.

The projectile from Round No. 25 which was photographed with microflash equipment is obscured in what appears to be a combination of muzzle gas and particles of the styrofoam portion of the projectile. The degree of distortion and/or yaw (if any) is, therefore, not discernable (see Figure 2). (Note: Extending the interval between the strobes of the microflash system and increasing the field of view of the camera in any subsequent firings of this projectile at this velocity should result in one (1) or more exposures of the projectile after it has cleared this muzzle opacity.)

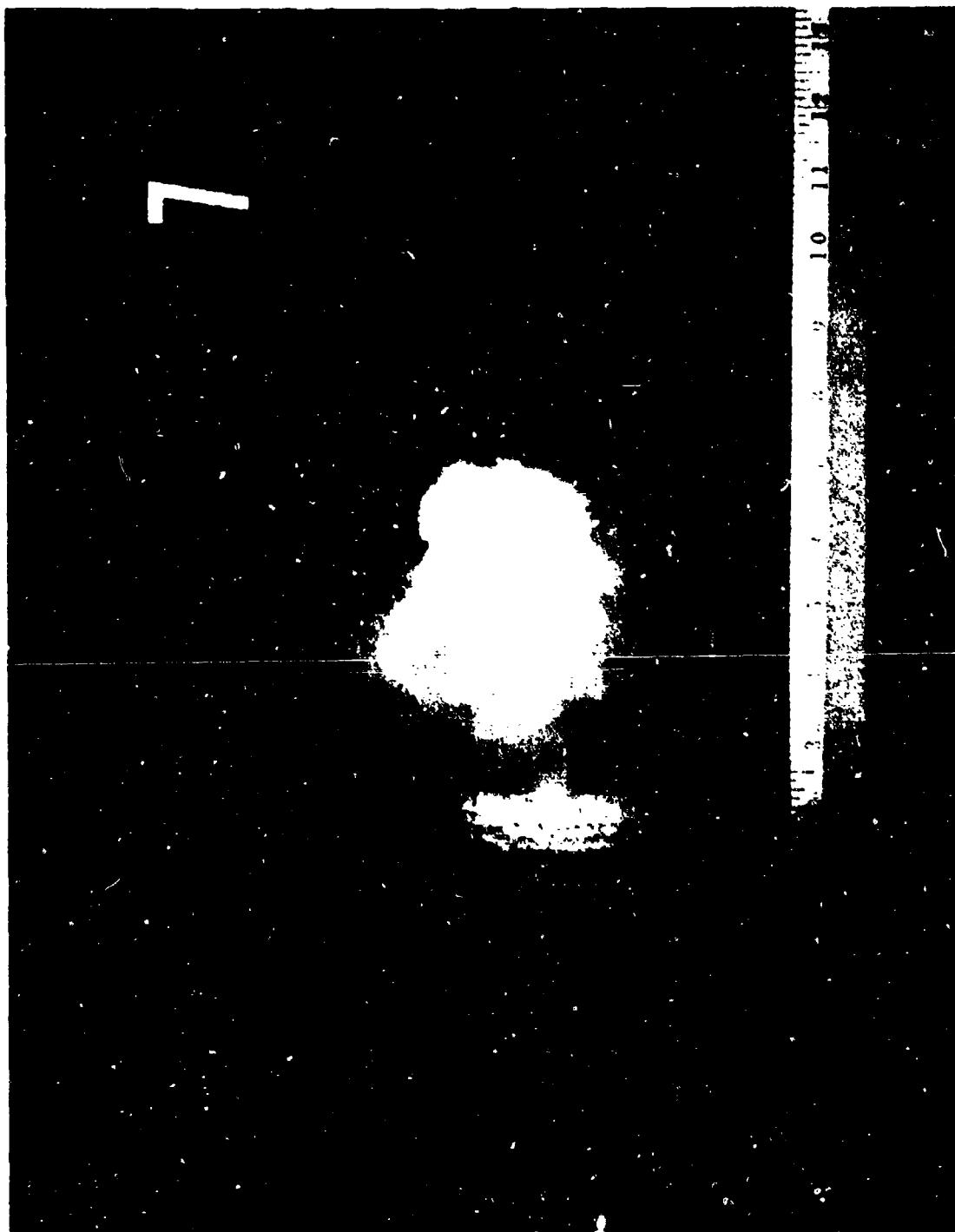


Figure 2. Muzzle Exit of Round No. 25.

APPENDIX A

Date 4 October 1975

Temperature 70°F ; Humidity 8.5

2-Meter Screens 5.06' and 8.06' (over 5')

5-Meter Screens 14.90' and 17.90' (over 17.5')

Shooter Pool

Recorder Sunbelt

Chronograph Dohler

Chronograph L.C.

2-Meter

Proj.

Wt.

Time

Shot No.

(sec)

(ft/sec)

(gm.)

S-Meter

Proj.

Wt.

Time

Shot No.

(sec)

(ft/sec)

(gm.)

Vel.

Proj.

Wt.

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Vel.

Proj.

Wt.

Time

Shot No.

(sec)

(ft/sec)

(gm.)

Vel.

Proj.

Date 2 October 1973 Job No. 1883-11Temperature 70°F; humidity 85%Recorder Swartz Page 1Chronograph I.C. Weapon M1200 #1571489Chronograph Screens 5.0ft and 8.0ft (over 5') Ammunition 5" Liquid BallChronograph Screens 14.90ft and 17.90ft (over 5') Type Lot 20 meters

S	No	2-Meter reading	2-Meter		5-Meter		Proj. wt.* (lb.)	Proj. wt. (lb.)	Coordinates X (in.)	Y (in.)	Aiming Data	Indent. in. Minnesota (in.)	Results
			Tire No.	Vel. (ft/sec)	Tire No.	Vel. (ft/sec)							
9	24214	123.9	4257.1	24460	122.6	4257.1	-2.0	-57.0	3° Elevation	0			
10	21476	139.7	4257.1	21850	137.4	4257.1	-7.0	-57.0		0			
11	21467	139.7	4257.1	21768	137.8	4257.1	+ 1.7	-59.0		0			
12	22580	132.9	4257.1	22851	131.4	4257.1	-17.8	-58.6		0			
13	24425	122.8	4257.1	24887	120.5	4257.1	-25.3	-61.0		0			
14	No reading												
15	22728	132.0	4257.1	22986	130.5	4257.1	0	-59.6		0			
16	25537	127.4	4257.1	32197	93.2	4257.1	-6.0	-81.5		0			

*Average weight.

Date 25 September 1955 Shooter Pilot
 Temperature 62°F; Humidity 81% Recorder 14 JHR
 2-Meter Screens 3 and 3 (over 1) Chronograph
 5-Meter Screens 2 and 2 (over 1) Chronograph

Type 5" Liquid Ball
 Target 50 meters
 Lot

Shot No.	Time (sec)	2-Meter Vel. (ft/sec)	S-Meter Proj. Wt.* (gr.)	Proj. Wt. (in.)	Coordinates (in.)	Aiming Data	Results	
							x	y
25	Hero flash	4257.1	4257.1	4257.1	Aiming point 6' 14" up from floor	Aiming point 6' 14" up from floor	Projectile hit approximately 6' to left of center line and behind target.	

Date 19 September 1975
 Temperature 60° F; Humidity 71
 2-Meter Screens _____ and _____ (over _____)
 5-Meter Screens _____ and _____ (over _____)

Shooter Double

Recorder 11 ft

Chronograph

Chronograph

Type Lot
 Target 50 meters

Weapon 11 Gun, M1200 #151489
 Ammunition 3" Liquid shell

Shot No.	2-Meter Time (sec.)	S-Meter Proj. Wt. (ft/sec.) (gm.)	Proj. Vel. Time (sec.) (ft/sec.) (gm.)	Coordinates X Y (in.)	Aiming Data	Indent. in. Score (in.)	Results	
							Wt.* (gm.)	Y (in.)
20	Black and White High Speed Movie	Speed Movie	4557.	Aiming point of impact				

*Average weight.

Date September 1883

Temperature 65°; Humidity

2-Meter Screens and (over)

Screens and (over)

Shooter _____
 Recorder _____
 Chronograph _____
 Chronograph _____
 Type _____
 Lot _____
 Target feet
 meters

2-Meter	S-Meter	Coordinates	Aiming Data	Indent. in concrete (in.)	Results	
Shot No.	Time (sec)	Proj. Wt. (lb.)	Vel. (ft/sec)	Time (sec)	Y (in.)	X (in.)
						Impact floor at 10 ft and supports of target.
						Survey of target.

Color high speed shot

Weight

Average weight.

Date 25 November 1975

Temperature 50° F Barometric 60

2-Meter Screens (over) 400

5-Meter Screens (over) 400

Shooter No. 1883-1

Page

Revolving Gun

Ammunition 10000 ft

Type 10000 ft

Target 50 meters

HITTING

Shot No.	2-Meter Proj. At Time (sec)	5-Meter Proj. At Time (sec)	Coordinates (ft sec)	Aiming Data	Results	
					X	Y
28					-10.0	-40.1
29					-17.0	-40.3
30					-15.5	-44.5
31					+15.5	-41.7
32						

Date 25 November 1975 Job No. 1883-11
 Temperature 55° F., humidity 60% Recorder Siemens
 2-Meter Screens and (over) Chronograph
 5-Meter Screens and (over) Type 35 meters

1130 PIR						
Shot No.	Time (sec.)	Z-Meter Proj. Wt. (gr.)	S-Meter Proj. Wt. (gr.)	Coordinates		Indent. in Fiberscopic Results (in.)
				Vel. (ft/sec.)	Time (sec.)	
				x (in.)	y (in.)	Aiming Data
35				+19.0	-41.0	Miss. Point only
34				-9.3	-45.5	Miss. Point only
35				-25.5	-46.1	Miss. Point only
36				+24.5	+50.0	Miss. Point only
37				+2.9	-34.8	Miss. Point only

Date 25 November 1973

Job No. 1893-11

Telescope 2nd; Batimity 00
 2-Meter Screens and (over)
 5-Meter Screens and (over)

Recorder 1 hole
 Chronograph
 Chronograph
 Type Lot
 Target 55 meters

113D TIR

Shot No.	Time (sec.)	2-Meter Proj. Vel. (ft/sec.)	5-Meter Proj. Vel. (ft/sec.)	Coordinates		Aiming Data	Indent. in front of target (in.)	Results
				X (in.)	Y (in.)			
38				-20.5	-42.0	Miss.	Point only	Missed
39				*-7.1	-11.1	Miss.	Point only	Missed
40				*11.5	-10.0	Miss.	Point only	Missed
41				*10.0	-0.0*	Miss.	Point only	Missed. Broke in flight. Hit floor at approx 32m.
42				+50.5	-41.9	Miss.	Point only	Missed

*Approximately

OBSERVED DATA

MAXIMUM RANGE
**M1200-Launcher 3-Inch Liquid Ball
Barrel Elevated 30°**

Date: 5 February 1974

Temperature: 30°F, variable
cross wind (left to right)

OBSERVED DATA

COLD TEST

M1200 Launcher 3-Inch Liquid Ball

Date: 12 February 1974

Ammunition: Stored at -45°F for 24 hours.

Stored at 0°F for 1 hour immediately before firing.

Machine rest, lanyard fired

Target: 35 meters

Aiming point: 100 inches high

Round No.	(in.)	(in.)	Indentation (in.)	Remarks
46	--	--	--	Hit floor at 25 meters.
47	--	--	--	Hit floor at 32 meters.
48	--	--	--	Hit floor at 35 meters, bounced to target.

OBSERVED DATA

MAXIMUM EFFECTIVE FIRING RANGE
ML200 Launcher - 5-Inch Liquid Ball

Date: 1 March 1974

Temperature: 45°F, variable cross wind
right to left

Round No.	Impact coordinates (in.) x y	Silhouette Hit/ Missed	wind Velocity (m.p.h.)	Flight Time (sec.)	Projectile Weight (gr.)	Remarks
TARGET DISTANCE: 35 METERS						
49	- -	Missed	9.0	-	475.1	hit ground at 31m
50	- -	Missed	10.0	-	4250.1	hit ground at 30m
51	+14.0 -46.9	Missed	10.0	0.9	4245.8	
52	- -	Missed	10.5	-	4559.5	hit ground at 31m
TARGET DISTANCE: 20 METERS						
53	0 -46.5	hit	10.0	0.5	4559.5	
54	0 -45.5	hit	10.0	0.5	4590.4	
55	- -	Missed	11.0	-	4550.4	hit ground at 18.5m

APPENDIX B

CALCULATED DATA

ACCURACY

3-Inch Liquid Ball
6.4 Meters

CALCULATED DATA

ACCURACY
3-Inch Liquid Ball
20 Meters

Round No.	Coordinates (in.)		Calculations		Radius (in.)
	x	y	$(x - \bar{x})^2$	$(y - \bar{y})^2$	
9	-2.0	-57.0	37.21	25.0	7.9
10	-7.6	-57.6	0.25	19.36	4.4
11	+1.7	-59.0	96.04	9.0	10.2
12	-17.8	-58.6	94.09	11.56	10.3
13	-25.3	-61.0	295.84	1.0	17.2
15	0	-59.6	65.61	5.76	8.4
16	-6.0	-81.3	4.41	372.49	19.4
<hr/>					
Standard Deviation			x (in.)	y (in.)	---
	---	---	9.9	8.6	
Mean	$\bar{x} = -8.1$	$\bar{y} = -62.0$	---	---	11.1
Extreme Spread	27.0	24.3	---	---	---

CALCULATED DATA

ACCURACY
Timed Fire
3-Inch Liquid Ball

Round No.	Coordinates (in.)		Calculations		Radius (in.)
	x	y	$(x - \bar{x})^2$	$(y - \bar{y})^2$	
28	-12.3	-44.5	6.25	1.21	2.7
29	-20.7	-46.1	118.81	7.29	11.2
30	-17.0	-40.3	51.84	9.61	7.8
31	-12.5	-44.5	7.29	1.21	2.9
32	+13.7	-41.7	552.25	2.89	23.6
<hr/>					
Standard Deviation			x (in.)	y (in.)	---
	---	---	13.6	2.4	
Mean	$\bar{x} = -9.8$	$\bar{y} = -43.4$	---	---	9.6
Extreme Spread	34.4	5.8	---	---	---

CALCULATED DATA

ACCURACY
Timed Fire
3-inch Liquid Ball

Round No.	Coordinates (in.)		Calculations		Radius (in.)
	x	y	$(x - \bar{x})^2$	$(y - \bar{y})^2$	
53	+19.0	-44.0	278.89	400.00	26.1
54	-9.3	-45.3	134.56	453.69	24.3
55	-25.5	-46.1	772.84	488.41	35.5
56	+24.5	+50.0	492.84	5476.00	77.3
57	+2.9	-34.8	0.36	116.64	10.8
<hr/>					
Standard Deviation			x (in.)	y (in.)	---
	---		20.5	41.6	
	Mean $\bar{x} = +2.3$		---	---	
Extreme Spread	$\bar{y} = -24.0$		---	---	34.8
	50.0		96.1	---	

CALCULATED DATA

ACCURACY
Timed Fire
3-Inch Liquid Ball

APPENDIX C

TEST INSTRUMENTATION
EQUIPMENT AND MATERIALS

- 1 - Oehler Model 41B Chronotach, calibrated at factory in May 1973
- 1 - Electronic Counters, Inc. Model 4010 Velocity Computing Chronograph, calibrated at factory in June 1973
- 4 - Oehler Model 35 Lumiline Screens
- 2 - Eastax 16mm High Speed Motion Picture Cameras
- 1 - Wollensak Model 3106 Time Pulse Generator
- 2 - Colortran 1000 Watt Lights
- 2 - Wollensak 1000 Watt Lights
- 2 - 100-foot Rolls Kodak Ektachrome (7242) 16mm High Speed Film (GFE)
- 2 - 100-foot Rolls Eastman Double-X Negative (722) 16mm High Speed Film
- 1 - Vanguard Model 16C Motion Analyzer
- 4 - General Radio Type 1539 "Stroboflash" Microflash
- 1 - General Radio Model 1541 Multi-Flash Generator
- 1 - Linhof 4x5 Camera with Kodak f4.5, 135mm Lens
- 1 - Royal Pan 4" x 5" Cut Film, Type 4141
 - Various darkroom and photographic equipment
 - 100-meter indoor range having ceiling height of 12 feet
 - 400-meter outdoor range
 - Miscellaneous range supplies and equipment
- 1 - Specially constructed target (Homasote faced), Homasote Company, Lower Ferry Road, Trenton, N.J.
- 1 - Dry Ice Freezer Unit
- 1 - Rochester Thermometer
- 1 - Plywood Anthropometric Silhouette Target based on 1960 Dreyfus data
- 1 - Dwyer Wind Meter, F.W. Dwyer Mfg Co., Michigan City, Indiana

APPENDIX D

AAI CORP. - MODEL C-200
Blank Propelling
Cartridges
FOR USE WITH
MPG SERIES GRENADES
Aero
MODEL L-110 LAUNCHERS

APPENDIX D
40mm Liquid Ball
(Test Firing)

TEST REPORT
LESS LETHAL 40MM LIQUID BALL-1

(TASK 02-F-73, CONTRACT
NO. DAAD05-73-C-0532
WORK ORDER NO. 10)

Prepared For

United States Army
Land Warfare Laboratory
Aberdeen Proving Ground, Maryland

By

H.P. White Laboratory
Bel Air, Maryland

February 1974

P-3

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ABSTRACT

This report presents the results of initial tests of less-lethal 40mm Liquid Ball rounds in accordance with the provisions of Contract No. DAAD03-73-C-0532, Task 02-1-73 (an agreement between the U.S. Army Land Warfare Laboratory and H.P. White Laboratory).

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SECTION I. SCOPE OF WORK

1. OBJECTIVE

The objective of these tests was to provide the external ballistic data necessary to assess the ballistic performance of the 40mm Liquid Ball less lethal ammunition.

2. MATERIALS

The following materials were used in the conduct of this test program:

- a) 40mm Liquid Ball less lethal projectiles (see Figure 1).
- b) Grenade launcher, 40mm, M79, Serial No. 47637.
- c) Miscellaneous range and photographic equipment (see Appendix C).

3. SCOPE OF TESTS

Seventy-eight (78) rounds of 40mm Liquid Ball ammunition were fired on an instrumented indoor range to determine velocity, accuracy, muzzle exit phenomena, relative impact characteristics and the effect of shooter stress on accuracy. Ten (10) rounds were fired on an outdoor range to determine maximum range and maximum effective hitting range when the projectiles are subjected to environmental variables such as wind. Seven (7) rounds were fired to determine the effect of cold temperature firing. (see Table 1)

TABLE I. SCOPE OF TESTS

Round No.	Muzzle Velocity	Impact Coordinates	Nozzle Exit Phenomena	Impact Phenomena	Cold Test	Maximum Range	Maximum Effective Hit Range	Shooter Stress
	Muzzle 2m	5m	Muzzle 2m	5m				
	LS	LS	C	C	A	A	A	A
1-21								
22	HS							
23-26								
27-30								
31-37	HS		C					
38-48								
49-78								
79-81								
82-88								
89-95								

T,A
A
A,E

HS - High Speed Motion Picture

LS - Lumiline Screens/Time Interval Counter

MF - Micro Flash

C - Calculated

A - Measured

T - Timed

E - Estimated

SECTION II. PROCEDURE

1. VELOCITY

- a) The velocity of twenty-one (21) rounds of the 40mm Liquid Ball projectiles was derived from data collected by erecting lumiline screens 5.06, 8.06, 14.9 and 17.9 feet (1.54, 2.46, 4.54 and 5.46 meters, respectively) from the muzzle of an M79 Grenade Launcher fired from the prone/rest position. The outputs of these screens activated time interval counters from which the velocities at 2 and 5 meters from the muzzle were calculated.
- b) Velocity of eight (8) of the 40mm Liquid Ball projectiles was calculated from data extracted from high speed motion pictures of the muzzle and initial few feet of projectile flight recorded by 16mm Fastax motion picture cameras positioned 4 feet 8 inches to the right of the line of fire and 9 inches in front of the muzzle. The film speed, used to compute the projectile velocity, was determined from timing marks on the film created by a time pulse generator.

2. PROJECTILE ENERGY

Projectile energy of the 40mm Liquid Ball projectile was calculated by applying the unfired projectile weight and the velocity data derived per 1, above, to the standard energy formula--

$$\text{Kinetic Energy} = (1/2) MV^2$$

3. ACCURACY

The accuracy of the 40mm Liquid Ball ammunition was determined from the impact data on a target constructed of 2" x 4" wood backing, 1/2-inch thick Homasote and faced with paper. The accuracy of the ammunition was determined by measuring the horizontal and vertical dispersion from the aiming point on the target. Standard deviations in the x and y directions and the mean radius were calculated.

4. IMPACT CHARACTERISTICS

Indentations in the Homasote, produced by each projectile impact, were measured using a depth micrometer and the average indentation was calculated. Indications of projectile attitude at impact were observed and noted. These data were collected from the target when positioned 6.4, 20, 35, 50 and 70 meters from the muzzle of the prone/rest fired M79 Grenade Launcher.

5. EFFECT OF SHOOTER STRESS ON ACCURACY

Three (3) shooters fired ten (10) rounds each at an anthropometric silhouette target positioned 35 meters from the shooter. In order to induce stress, each shooter was told that he would have an average of 4 seconds (varying from 3 seconds to 5 seconds) to shoulder the M79, sight and fire at the target. This timing was accomplished by utilizing a cardboard shield which obscured the shooter's view of the target before and after each shot. No warning was given before the shield was raised and the time interval started. The coordinates of each shot in relation to the crotch area of the silhouette were recorded. Whether or not a hit had been scored on the man-size silhouette was recorded and any hits in critical areas (groin and eyes) were noted. Standard deviation of the x and y coordinates and the mean radius were calculated from these data.

6. MAXIMUM RANGE

The M79, with its barrel elevated 30° from horizontal, was fired from a bench rest on a 400-meter outdoor range. After each shot, the distance the projectile traveled before its initial impact with the ground was measured as well as the deflection right or left of the line of sight.

7. MAXIMUM EFFECTIVE HITTING RANGE

The M79 Grenade Launcher was bench rest fired at an anthropometric silhouette target positioned 50 meters from the muzzle. After two (2) firings without scoring a hit on the silhouette, the target was moved to 35 meters. After three (3) firings without scoring a hit on the silhouette, the target was moved to 20 meters for the remaining two (2) firings. Wind velocity at each firing was measured using a Dwyer Wind Meter. Silhouette target hits and misses, impact coordinates, and flight time from muzzle to target (timed by stop watch) were recorded. Estimate of the maximum effective hitting range was the average of three (3) observers opinion of range at which tactical hits could be expected under test conditions.

8. COLD TEMPERATURE FIRING

Seven (7) of the 40mm Liquid Ball projectiles were stored at -45°F for 24 hours. They were then stored for one additional hour at 0°F immediately before being fired from the machine rest mounted M79 Grenade Launcher. Each shot was fired remotely. The fired cartridge case and the M79 Grenade Launcher were examined for damage after each shot. Impact coordinates and the indentation in the Homasote faced target were measured and recorded.

9. MUZZLE EXIT PHENOMENA

Twelve (12) 40mm Liquid Ball projectiles were photographed as they exited the muzzle of the launcher. Eight (8) rounds were photographed using two (2) 16mm Fastax high speed motion picture cameras simultaneously. One Fastax camera was positioned perpendicular to and 4 feet 8 inches from the line of fire, 9 inches forward of the muzzle. The other Fastax camera was positioned 38.3 feet forward of the muzzle, 3 feet to the left of the line of fire and focused on the muzzle. Both cameras ran at a nominal 4000 frames per second. Four (4) rounds were photographed using a Linhof 4" x 5" camera positioned 4 feet to the right and 1 foot in front of the muzzle. Four (4) General Radio "Stroboslave" recycling flash units were pulsed at .0013 second intervals for a flash duration of .000003 seconds each. These strobes provided four (4) exposures of the projectile within 14 inches of the muzzle. Projectile muzzle exit was studied by examining the 16mm high speed motion picture film and enlargements of the 4" x 5" microflash photographs (see Figures 2 thru 5).

10. SAFETY

In addition to normal safety procedures followed during firing, personnel were required to wear respiratory protection during conduct of the test to preclude inhalation of any small droplets of the glycerin and water mix in the projectile which might have been aerosolized upon target impact.

SECTION III. RESULTS

1. VELOCITY

Table II is a summary of the velocity data contained on the data sheets of Appendix A.

TABLE II. RESULTS OF VELOCITY TESTS (f.p.s.)
40mm Liquid Ball

	Muzzle** (8 rds)	2m* (21 rds)	5m* (21 rds)
Maximum	305.5	270.1	262.6
Minimum	253.9	225.8	220.2
Average	275.4	245.9	239.2

*Lumiline screens/time interval counter
(accuracy ± 5 f.p.s.)
**High Speed Motion Pictures
(accuracy ± 20 f.p.s.)

2. PROJECTILE ENERGY

Table III is a summary of calculations based on the data contained in Appendix A.

TABLE III. PROJECTILE ENERGY (ft-lbs)
40mm Liquid Ball

	Muzzle	2m	5m
Maximum	95.2	74.5	70.5
Minimum	65.9	51.2	49.5
Average	77.9	62.0	58.6

3. ACCURACY

Table IV is a summary of calculations based on the data contained in Appendix A.

TABLE IV. RESULTS OF ACCURACY TESTS
40mm Liquid Ball

Target Distance (meters)	Group Center (from point of aim) (in.)		Extreme Spread (in.)		Standard Deviation (in.)		Mean Radius (in.)
	x	y	x	y	x	y	
6.4	-0.2	+8.0	3.2	5.6	1.5	2.0	1.9
20	+0.5	+10.2	52.8	64.9	35.7	22.2	31.9
35	-21.5	+16.6	56.5	75.8	18.4	22.5	21.8
50	+39.5	-10.0	59.4	85.5	21.0	29.0	25.6
70	+14.8	-5.4	25.8	48.4	8.6	15.4	12.8

4. IMPACT CHARACTERISTICS

Table V is a summary of calculations based on the data contained in Appendix A.

TABLE V. INDENTATIONS OF EOMASOTE
40mm Liquid Ball

Target Distance (meters)	Average Indentation (in.)	Minimum Indentation (in.)	Maximum Indentation (in.)
6.4	.160	.070	.196
20	.019	0	.051
35	.038	.031	.044
50	.012	0	.040

5. EFFECT OF SHOOTER STRESS ON ACCURACY

Table VI is a summary of the calculations based on the data contained in Appendix A.

TABLE VI. SUMMARY OF STRESS TEST RESULTS
40mm Liquid Ball, Target 35 Meters

Shooter	Group Center (from point of aim)		Extreme Spread (in.)		Standard Deviation (in.)		Mean Radius (in.)	Total Hits on Silhouette	Hits in Critical Area
	x	y	x	y	x	y			
A	-4.2	+7.9	104.9	132.0	34.0	40.0	44.2	0	0
B	+17.8	+8.5	64.1	73.7	20.2	25.6	25.2	1	1
C	+10.6	+8.9	58.9	41.2	16.2	15.2	19.2	2	2

6. MAXIMUM RANGE

Table VII is a summary of the data contained in Appendix A.

TABLE VII. MAXIMUM RANGE
40mm Liquid Ball

	Distance (meters)	Deflection (meters)
Maximum	122.0	5.0 right
Minimum	108.0	On line of sight
Average	115.7	4.0 right

7. MAXIMUM EFFECTIVE HITTING RANGE

Table VIII is a summary of the data contained in Appendix A.

TABLE VIII. MAXIMUM EFFECTIVE HITTING RANGE
40mm Liquid Ball

Group Center (from point of aim) (in.)		Standard Deviation (in.)		Mean Radius (in.)	Hits	Wind Velocity (m.p.h.)	Average Flight Time (sec.)	Remarks
TARGET DISTANCE 50 METERS								
-	-	-	-	-	0	6.0-9.5	-	On round broke in flight
TARGET DISTANCE 55 METERS								
-79.9	+8.8*	56.8	12.4*	41.2*	0	9.5-12.0	0.3*	
TARGET DISTANCE 20 METERS								
-1.2	-12.8	9.5	2.1	6.8	2	11.0-12.0	0.2	
*2 rounds								

It was the opinion of the three (3) observers that the maximum effective range at which tactical hits on a man could be expected was approximately 20 meters.

8. COLD TEMPERATURE FIRING

Table IX is a summary of the data contained in Appendix A.

TABLE IX. COLD TEMPERATURE FIRING
(7 ROUNDS)
40mm Liquid Ball

Group Center (from point of aim) (in.)		Standard Deviation (in.)		Mean Radius (in.)	Indentation in Fibrosote (in.)	Remarks
x	y	X	Y			
+5.1	+10.5*	20.0	14.4*	20.4*	.025*	
*5 rounds only						

Projectile filler (60% glycerin, 40% water) appeared to be in a solid state at impact. Dispersal characteristics appeared to be reduced to approximately

1/3 the size of those fired at room temperature. Two (2) of the seven (7) rounds did not reach the target--one was observed to break in flight and we were unable to account for the other. The mean radius of the five (5) measureable impacts (20.4 inches) cannot be directly compared to the mean radius of 21.8 inches from the room temperature firing.

9. MUZZLE EXIT PHENOMENA

The muzzle exit of twelve (12) rounds were recorded photographically--eight (8) with high speed motion pictures and four (4) with multistrobed microflash.

Analysis of the film revealed:

- a) Rounds number 34 and 36 show the projectile spilling its liquid filling near the muzzle.
- b) Ten (10) of the films show the sabot opening and no apparent abnormalities.
- c) Four (4) of the films were ruined in development.
- d) One of the four microflash (Figure 4) shows the projectile spilling liquid.

APPENDIX A

Date 4 October 1973
 Temperature 70°F; Humidity 85%
2-Meter Screens 5.06' and 8.06' (over 3')
5-Meter Screens 14.90' and 17.90' (over 3')

Shooter Poule
 Recorder Sunkwalt

Chronograph Oehler
 Chronograph L.C.
 Type --
 Target 6.4 meters

Job No. 1883-10
 Page 1
 Weapon M79 #47637
 Ammunition 40mm Liquid Ball
 Lot --

Shot No.	2-Meter			5-Meter			Coordinates			Aiming Data			Indent. in. Hamasote (in.)			Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt.* (gr.)	Time (sec)	Vel. (ft/sec)	Proj. Wt.* (gr.)	X (in.)	Y (in.)	obturator	X (in.)	Y (in.)	obturator	X (in.)	Y (in.)		
1	13238	226.6	460.0	13603	220.5	160.0	-0.3	+7.0	Level 1	23	1/4"	-3.2	+2.5	no identification	.070	Sabots penetrated flash shield homasote.
2	11068	270.1	460.0	11424	262.6	460.0	0.0	+8.9	Level 1	23	1/4"	-2.0	-5.4		.171	Sabot imbedded in flash shield all broke/wet screens
3	12867	234.2	460.0	13181	227.6	460.0	+1.5	+10.4	obturator	+5.5	+7.1				.170	
4	12204	245.8	460.0	12597	238.2	460.0	+1.3	+7.4	obturator						.151	
5	12069	248.6	460.0	12460	240.8	460.0	-1.7	+6.1							.171	
6	11755	255.2	460.0	12004	249.9	460.0	-1.3	+8.8							.196	
7	11493	261.0	460.0	11809	254.0	460.0	-1.1	+11.7							.190	

*Average weight.

Date 1 October 1975

Temperature 68°F ; Humidity 80%

2-Meter Screens 5.06' and 8.06' (over 5')

5-Meter Screens 4.90' and 17.90' (over 5')

Shooter pool.

Recorder

Summit

Chronograph

Schlier

Cronograph

E.C.

Target

20 meters

Job No. 1683-11

Page

Weight 17.9 = 470.5

Armament 40mm Liquid ball

Type

--

Lot

--

Shot No.	2-Meter			5-Meter			Coordinates			Aiming Data	Indent. in. from nose (in.)	Results
	Time (sec.)	Vel. (ft/sec.)	Proj. Wt.* (gr.)	Time (sec.)	Vel. (ft/sec.)	Proj. Wt.* (gr.)	X (in.)	Y (in.)	Z (in.)			
8	111574	259.2	460.0	111910	251.9	460.0	+24.5	-55.9	5° Elevation		0	Sabot broke. Photographed see figure 6.
9	121128	247.5	460.0	12492	240.2	460.0	+9.5	+15.7	5° Elevation		.011	
10	13203	227.2	460.0	13198	222.5	460.0	-10.9	+23.6	5° Elevation		.045	
11	111143	269.2	460.0	11782	254.6	460.0	+17.2	+24.9	5° Elevation		0	Hit top of 17.9' screen
12	11756	255.6	460.0	11975	250.5	460.0	+59.5	+29.0	5° Elevation		0	Sabot broke
13	12361	242.7	460.0	12584	238.4	460.0	-15.3	+10.4	5° Elevation		.051	Sabot broke
14	13404	225.8	460.0	13625	220.2	460.0	-63.0	+5.3	5° Elevation		0	

*Average weight.

Date	1 October 1973	Shooter	Poole	Job No.	1883-10
Temperature	68°F ; Humidity 80%	Recorder	Sumwalt	Page	
2-Meter Screens	5.06' and 8.06' (over 3')	Chronograph	Oehler	Kepson	# 47037
5-Meter Screens	14.90' and 17.90' (over 3')	Chronograph	E.C.	Ammunition	40mm Liquid Ball
Type	--	Lot	--	Target	35 meters

Shot No.	2-Meter			5-Meter			Coordinates Proj. Wt.* (gn.)	Aiming Data	Indent. in Homasote (in.)	Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt.* (gn.)	Time (sec)	Vel. (ft/sec)	Proj. Wt.* (gn.)				
15	12137	247.2	460.0	12512	239.8	460.0	-26.2 +5.9	Gun muzzle 3° Elevation	.042	One sabot completely penetrated homasote 3' in front of muzzle.
16	12360	242.7	460.0	12615	257.8	460.0	-41.7 -54.5	Muzzle 3° Elevation	.031	Sabot - interior wet and one penetrated homasote 3' in front of muzzle.
17	12693	236.4	460.0	13046	230.0	460.0	+14.8 +24.2	Muzzle 3° Elevation	.032	Sabot penetrated flash shield 3' in front of muzzle. Broken sabot.
18	12705	249.8	460.0	12393	242.1	460.0	-17.4 +8.7	Muzzle 3° Elevation	.044	
19	12722	235.8	460.0	13130	228.5	460.0	-37.5 +17.1	Muzzle 3° Elevation	.033	Sabot penetrated flash shield
20	11749	255.3	460.0	12105	247.8	460.0	-19.0 +17.1	Muzzle 3° Elevation	.042	Broken sabot
21	12992	230.9	460.0	13251	226.4	460.0	-22.4 -21.3	Muzzle 3° Elevation	.039	

*Average weight.

Date 7 September 1973
 Temperature 65°F; Humidity --
 2-Meter Screens -- and -- (over --)
 5-Meter Screens -- and -- (over --)

Shooter Poole
 Recorder Flohr
 Chronograph --
 Chronograph --
 Type --
 Target 50 meters

Page 1
 Wcapon M9 47.057
 Ammunition 40mm Liquid Ball
 Lot --

Shot No.	2-Meter			5-Meter			Coordinates X (in.) Y (in.) Z (in.)	Aiming Date	Indent. in. Monksote (in.)	Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gm.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gm.)				
22	Color High Speed Movie						+84.0*	-20.0*	Level 25 1/4"	Did not impact 8'x 8' target.
25							+23.4	-2.2	Level 25 1/4"	.150 Bounced prior to impacting 8'x 8' target
24							+72.0*	-63.0*	Barrel 4° Elevation aiming point 66 1/4"	Ball hit floor 3' in front of target and missed 8'x 8' target. Ball found cracked but not broken. Wet spots on floor at 33m, inside of sabot wct.
25							+35.1	-7.5	Barrel 4° Elevation aiming point 66 1/4"	.050
26							+52.4	-15.6	Barrel 4° Elevation aiming point 66 1/4"	0

*Approximately

Date 25 September 1973
 Temperature 62°F; Humidity 81%
 2-Meter Screens -- and -- (over --)
 5-Meter Screens -- and -- (over --)
 Target 50 meters

Job No. 1883-10

Page

Wcapon M79 #47637

Ammunition 40mm Liquid Ball

Type -- Lot --

Shot No.	2-Meter			5-Meter			Coordinates X (in.)	Aiming Data	Indent. in. Homasote (in.)	Results
	Time (sec)	Vel. (ft/sec)	proj. Wt. (gm.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gm.)				
27	Micro Flash						+54.9	-5.5	Aiming point 61 1/4" up from floor	.040

Date 1 November 1973 Shooter Pocle Job No. 1883-10
 Temperature 54°F; Humidity 66% Recorder Sunwalt Page 1
 2-Meter Screens -- aud. -- (over --) Chronograph --
 5-Meter Screens -- and -- (over --) Chronograph --
 Target 50 meters

Shot No.	Time (sec.)	Vel. (ft/sec.) (gn.)	Proj. Wt. (sec.)	S-Meter Time (sec.)	Coordinates Wt. (ft/sec.) (gn.)	Aiming Data (in.)	Results	
							x (in.)	y (in.)
28	Micro flash				-	Level 23 1/4"	-	
29	Micro flash				+10.7	-14.4	Level 23 1/4"	
30	Micro flash						0	Hit pipe on left side of range approximately 5' behind target and 19" above floor. Ball passed target approximately 6' to left of center.

Date	19 September 1973	Shooter	Poolc	Job No.	1883-10
Temperature	60°F ; Humidity	Recorder	Flohr	Page	
2-Meter Screens	-- and -- (ovcr --)	Chronograph	--	Weapon	N79 #47657
5-Meter Screens	-- and -- (over --)	Chronograph	--	Ammunition	40mm Liquid Ball
		Type	--	Lot	--
		Target	50	meters	

Shot No.	2-Meter			5-Meter			Coordinates X (in.)	Aiming Data	Indent. in. Housote (in.)	Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)				
31	Black and White	High Speed	Novice				Aiming point 61 1/4" up from floor.			Projectile did not impact 8' x 8' target - apparently went over top of target sabots found at 22m, 35m, 27m, and 7m

Date	13 November 1975	Shooter	Poole	Job No.	1883-10	
Temperature	50° F	Humidity	65%	Recorder	Sunwalt	
2-Meter Screens	... and ...	(over ...)	Chronograph	...	Page	117
5-Meter Screens	... and ...	(over ...)	Chronograph	...	Weapon	= 47637

Ammunition	40mm Liquid Ball
Type	...
Target	N/A

meters

Shot No.	2-Meter			5-Meter			Coordinates x (in.)	Aiming Data	Indent. in. Bombsite (in.)	Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)				
52	16mm (Color High)	Speed	Movies				Not taken			
53	16mm (Color High)	Speed	Movies	Make up			Not taken			

Date	30 October 1975	Shooter	Poole	
Temperature	50°F; Humidity	68%	Recorder	Sigmundt
2-Meter Screens	-- and --	(over --)	Chronograph	--
5-Meter Screens	-- and --	(over --)	Chronograph	--
			Type	--
			Target	50 meters

Job No. 1883-10

Page

Report No. 17637

Ammunition 40mm Liquid Ball

Type -- Lot --

Shot No.	2-Meter			5-Meter			Coordinates X (in.)	Y (in.)	Aiming Data	Indent. in. Housote (in.)	Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gm.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gm.)					
54	16mm Color High Speed	Movies	-	-	-	-	Level	23 1/4"	-	-	Broke open 5m from muzzle.
55	16mm Color High Speed	Movies	-	-	-	-	level	25 1/4"	-	-	Hit pipe on left side of range 5m from muzzle.
56	16mm Color High Speed	Movies	-37.8	-	-	-	Level	23 1/4"	-	-	Hit floor 54m from muzzle and rolled to target and hit base at x coordinate.
57	16mm Color High Speed	Movies	-15.5	+14.2	-	-	Level	23 1/4"	0	0	

Date 10 October 1975
 Temperature 68°F ; Humidity 81%
 2-Meter Screens -- and -- (over --)
 5-Meter Screens -- and -- (over --)

Job No. 1883-11

Shooter	Pool
Recorder	Surveillance
Chronograph	-
Chronograph	-
Type	40mm Liquid Ball
Target	50 meters

Page

Weather 47° F = 17.5° C

Ammunition 40mm Liquid Ball

Lot --

meters

Shot No.	2-Meter		5-Meter		Coordinates			Aiming Data	Indent. in hole(s) or in.:	Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)	X (in.)	Y (in.)		
58							+12.0	+22.5	4° Elevation	Broke open in flight.
59							+81.0*		4° Elevation	Missed 8' x 8' target.
40							-	+16.0*	4° Elevation	Missed 8' x 8' target.
41							+28.6	+7.0	4° Elevation	Broke open in flight.

*Approximately

Date 10 October 1975
 Temperature 68°F ; humidity 81%
 2-Meter Screens -- and -- (over --)
 5-Meter Screens -- and -- (over --)

Shooter Pow. Job No. 1885-11
 Recorder Sust.Malt Page 479
 Chronograph -- Weapon 1765
 Chronograph -- Ammunition 4 in Liquid Ball
 Type -- Lot --
 Target 70 meters

Shot No.	2-Meter Time (sec.)	Proj. Wt. (gn.)	Vel. (ft/sec.)	Time (sec.)	Proj. Wt. (gn.)	Vel. (ft/sec.)	Coordinates (in.)	Aiming Data	Indent in (Housote) (in.)	Results	
										S-Meter	5-Meter
42					+35.5	-5.1	7° Elevation on barrel		0		
43					-48.2	+6.3	7° Elevation on barrel		0		
44					-25.0	-8.4	7° Elevation on barrel		0		
45							7° Elevation on barrel		0		
46							7° Elevation on barrel		0		
47							7° Elevation on barrel		0		
48							-42.5	+8.6	0		

Date 21 November 1973

Temperature 58°F ; humidity 65%

Shooter Saubwalt " "

Recorder J Lohr

2-Meter Screens -- and -- (over --)

Page 179

5-Meter Screens -- and -- (over --)

Weapon M79

TIME) MIN

Ammunition 40mm Liquid Ball

Target 35 meters

Type --

Lot --

Shot No.	2-Meter			5-Meter			Coordinates			Aiming Data		Indent. in. from nose (in.)	Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt. (oz.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (oz.)	x (in.)	y (in.)	z (in.)	Angle	Angle		
49							+12.0	+19.5	.58	1/2"	from floor		Missed.
50							+10.0	-0.0	.58	1/2"	from floor		Missed.
51							0	+28.5	.58	1/2"	from floor		hit vital.
52							+21.0	+27.9	.58	1/2"	from floor		Missed.
53							+16.9	-6.7	.58	1/2"	from floor		Missed.
54							-25.8	-0.6	.58	1/2"	from floor		Missed.
55							+33.1	+20.5	.58	1/2"	from floor		Missed.
56							-0.5	+5.9	.58	1/2"	from floor		hit.
57							+19.4	-12.7	.58	1/2"	from floor		Missed.
58							+18.8	+14.8	.58	1/2"	from floor		Missed.

Date 21 November 1975

Temperature 58°F; Humidity 65%

Recorder Sunlight

Shooter Flohr "B"

Job No. 1883-10

Page

5

Weapon 170.5"

Chronograph --

Ammunition 40mm Liquid Ball

Type --

Lat --

Target 35

meters

2-Meter				5-Meter			
Shot No.	Time (sec.)	Proj. Wt. (ft/sec)	Time (sec.)	Vel. (ft/sec)	Proj. Wt. (gn.)	Coordinates (in.)	Aiming Data
59						+55.0 -25.0	10° up from floor
60						-11.1 +40.8	40° up from floor
61						+11.0 +28.4	40° up from floor
62						+12.2 +7.7	40° up from floor
63						+27.5 +15.5	40° up from floor
64						+27.1 +10.1	40° up from floor
65						- -	40° up from floor
66						+55.0 +18.5	40° up from floor
67						-8.2 +10.6	40° up from floor
68						+15.0 -32.9	40° up from floor

TIME FIRE							
2-Meter	Proj. Wt. (ft/sec)	Time (sec.)	Vel. (ft/sec)	Proj. Wt. (gn.)	Coordinates (in.)	Aiming Data	Indent in Hornsby (in.)
59					+55.0 -25.0	10° up from floor	Missed
60					-11.1 +40.8	40° up from floor	Missed
61					+11.0 +28.4	40° up from floor	Missed
62					+12.2 +7.7	40° up from floor	Missed
63					+27.5 +15.5	40° up from floor	Missed
64					+27.1 +10.1	40° up from floor	Missed
65					- -	40° up from floor	Broke in flight. Never reached target.
66					+55.0 +18.5	40° up from floor	Missed
67					-8.2 +10.6	40° up from floor	Hit
68					+15.0 -32.9	40° up from floor	Missed

Date	21 November 1973	Shooter	Poolle "V"	Job No.	1883-10					
Temperature	58°F ; Humidity 65%	Recorder	Stewart	Page						
2-Meter Screens	-- and -- (over --)	Chronograph	--	Weapon	179 #47157					
5-Meter Screens	-- and -- (over --)	Chronograph	--	Ammunition	40x7 Liquid Ball					
Type	--	Lot	--	Type	--					
Target	55 meters	TIME FIU.								
2-Meter	5-Meter	Coordinates	Aiming Data	Indent. in Homisote (in.)	Results					
Shot No.	Time (sec)	Proj. Wt. (gm.)	Vel. (ft/sec)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gm.)	x (in.)	y (in.)	Results	
69							+11.8	+17.4	48" up from floor	Missed
70							+4.2	-30.6	48" up from floor	Hit
71							+17.4	-6.7	48" up from floor	Missed
72							+27.9	+9.1	48" up from floor	Missed. Broke open in flight.
73							-24.0	+84.0	48" up from floor	Missed.
74							+19.5	+34.4	48" up from floor	Missed.
75							+15.9	-57.5	48" up from floor	Missed.
76							-47.1	+35.7	48" up from floor	Missed.
77							+11.8	+21.4	48" up from floor	Missed.
78							-77.0	-48.0	48" up from floor	Missed. Broke open in flight.

OBSERVED DATA

MAXIMUM RANGE
M79-40mm Liquid Ball
Barrel Elevated 30°

Date: 5 February 1974

Temperature: 30°F, variable wind
(left to right)

Round No.	Range (meters)	Deflection (meters)	Remarks
79	108	5.0-right	
80	122	4.0-right	
81	111	On line	

OBSEVED DATA

COLD TEST

40mm Liquid Ball

Date: 12 February 1974

Ammunition: Stored at -45°F for 24 hours.

Stored at 0°F for 1 hour immediately before firing.

Machine rest, lanyard fired

Target: 35 meters

Aiming Point: 47 1/2 inches high

Round No.	x (in.)	y (in.)	Indentation (in.)	Remarks
82	+12.2	+26.7	.025	Even spray on target.
83	+7.2	+5.3	.030	Even spray on target.
84	+29.6	-7.5	.013	Little spray on target.
85	-19.5	+4.3	.016	No spray on target. Round impact mark.
86	-14.1	+23.7	.043	No spray on target. Round impact mark.
87	Unk	Unk	Unk	
88	-	-	-	Ball broke in flight at approx 35 meters, sabot found wet inside and out.

OBSERVED DATA

MAXIMUM EFFECTIVE HITTING RANGE

40mm Liquid Ball

Date: 1 March 1974

Temperature: 45°F, variable cross wind
right to left

Round No.	Impact Coordinates (in.)		Silhouette Hit/ Missed	Wind Velocity (m.p.h.)	Flight Time (sec.)	Remarks
TARGET DISTANCE 50 METERS						
89	-	-	Missed	6.0	-	Broke in flight. Hit ground at 30m.
90	-	-	Missed	9.5	-	Hit ground at 40m.
TARGET DISTANCE 35 METERS						
91	-	-	Missed	9.5	-	Hit ground at 28m.
92	-39.7	+17.6	Missed	11.0	0.3	
93	approx -120.0	0	Missed	12.0	0.3	
TARGET DISTANCE 20 METERS						
94	-7.8	-14.2	Hit	11.0	0.2	
95	+5.4	-11.3	Hit	12.0	0.2	

APPENDIX B

D-54

CALCULATED DATA

ACCURACY
 40mm Liquid Ball
 6.4 Meters

Round No.	Coordinates (in.)		Calculations		Radius (in.)
	x	y	$(x - \bar{x})^2$	$(y - \bar{y})^2$	
1	-0.3	+7.0	0.01	2.56	1.6
2	0	+8.9	0.04	0.09	0.4
3	+1.5	+10.4	2.89	3.24	2.5
4	+1.3	+7.4	2.25	1.44	1.9
5	-1.7	+6.1	2.25	6.25	2.9
6	-1.3	+8.8	1.21	0.04	1.1
7	-1.1	+11.7	0.81	9.61	3.2
<hr/>					
Standard Deviation			x (in.)	y (in.)	---
	---		1.3	2.0	
Mean	$\bar{x} = -0.2$	$\bar{y} = +8.6$	---	---	1.9
Extreme Spread	3.2	5.6	---	---	---

CALCULATED DATA

ACCURACY
40mm Liquid Ball
20 Meters

Round No.	Coordinates (in.)		Calculations		k _a us (in.)	
	x	y	$(x - \bar{x})^2$	$(y - \bar{y})^2$		
8	+24.5	-35.9	576.00	2125.21	52.0	
9	+9.5	+15.7	81.00	30.25	10.5	
10	-10.9	+23.6	129.96	179.56	17.6	
11	+17.2	+24.9	278.89	216.09	22.2	
12	+39.5	+29.0	1521.00	353.44	44.3	
13	-15.3	+10.4	190.44	0.04	13.8	
14	-63.0	+3.8	4032.25	40.96	63.8	
Standard Deviation					---	
Mean	$\bar{x} = +0.5$	$\bar{y} = +10.2$	---	---	31.9	
Extreme Spread	52.8	64.9	---	---	---	

CALCULATED DATA

ACCURACY
40mm Liquid Ball
35 Meters

Round No.	Coordinates (in.)		Calculations		Radius (in.)
	x	y	$(x - \bar{x})^2$	$(y - \bar{y})^2$	
15	-26.2	+5.9	24.01	114.49	11.8
16	-41.7	+54.5	415.16	1436.41	43.0
17	+14.8	+24.2	1303.21	57.76	36.9
18	-17.4	+18.7	15.29	4.41	4.4
19	-37.5	+17.1	262.44	0.25	16.2
20	-19.0	+17.1	5.29	0.25	2.4
21	-22.4	-21.3	1.21	1436.41	37.9
<hr/>					
Standard Deviation			x (in.)	y (in.)	---
	---		18.4	22.5	
	$\bar{x} = -21.3$		---	---	
Mean	$\bar{y} = +16.6$		---	---	21.8
Extreme Spread	56.5		75.8	---	---

CALCULATED DATA

ACCURACY
40mm Liquid Ball
50 Meters

CALCULATED DATA

**ACCURACY
TIMED FIRE
40mm Liquid Ball**

Round No.	Coordinates (in.)		Calculations		Radius (in.)
	x	y	$(x - \bar{x})^2$	$(y - \bar{y})^2$	
49	+12.6	+19.5	4.00	112.36	10.8
50	+10.6	-0.6	0	90.25	9.5
51	0	+28.5	112.36	584.16	22.3
52	+21.0	+27.9	108.16	301.00	21.7
53	+16.9	-6.7	39.69	243.36	16.8
54	-25.8	-6.6	1324.96	240.25	39.6
55	+55.1	+20.5	506.25	134.56	25.3
56	-0.5	+3.9	125.21	25.00	12.2
57	+19.4	-12.7	77.44	460.56	23.3
58	+18.8	+14.8	67.24	54.81	10.1
<hr/>					
Standard Deviation			x (in.)	y (in.)	---
	---		16.2	15.2	
	Mean		$\bar{x} = +10.6$	$\bar{y} = +8.9$	
Extreme Spread	58.9		41.2	---	19.2
<hr/>					

CALCULATED DATA

ACCURACY
TIMED FIRE
40mm Liquid Ball

Round No.	Coordinates (in.)		Calculations		Radius (in.)
	x	y	$(x - \bar{x})^2$	$(y - \bar{y})^2$	
59	+53.0	-25.0	1239.04	1108.89	48.5
60	-11.1	+40.8	835.21	1056.25	43.5
61	+11.6	+28.4	38.44	404.01	21.0
62	+12.2	+7.7	31.36	0.36	5.6
63	+27.3	+16.5	90.25	67.24	12.5
64	+27.1	+10.1	86.49	3.24	9.5
65	--	--	--	--	--
66	+33.6	+18.5	249.64	104.04	18.8
67	-8.2	+10.6	676.00	5.29	26.1
68	+15.0	-32.9	7.84	1097.44	41.3
<hr/>					
Standard Deviation			\bar{x} (in.)	\bar{y} (in.)	---
	---	---	20.2	23.6	
Mean	$\bar{x} = +17.8$	$\bar{y} = +8.3$	---	---	25.2
Extreme Spread	64.1	73.7	---	---	--

CALCULATED DATA

**ACCURACY
TIMED FIRE
40mm Liquid Ball**

APPENDIX C

D-42

TEST INSTRUMENTATION
EQUIPMENT AND MATERIALS

- 1 - Oehler Model 41B Chronotach, calibrated at factory in May 1973
- 1 - Electronic Counters, Inc. Model 4010 Velocity Computing Chronograph, calibrated at factory in June 1973
- 4 - Oehler Model 35 lumiline Screens
- 2 - Fastax 16mm High Speed Motion Picture Cameras
- 1 - Wollensak Model 3106 Time Pulse Generator
- 2 - Colortran 1000 Watt Lights
- 2 - Wollensak 1000 Watt Lights
- 14 - 100-foot Rolls Kodak Ektachrome (7242) 16mm High Speed Film (GFE)
- 2 - 100-foot Rolls Eastman Double-X Negative (722) 16mm High Speed Film
- 1 - Vanguard Model 10C Motion Analyzer
- 4 - General Radio Type 1539 "Stroboflash" Microflash
- 1 - General Radio Model 1541 Multi-Flash Generator
- 1 - Linhof 4x5 Camera with Kodak f4.5, 135mm Lens
- 5 - Royal Pan 4" x 5" Cut Film, Type 4141
- Various darkroom and photographic equipment
 - 100-meter indoor range having ceiling height of 12 feet
 - 400-meter outdoor range
- Miscellaneous range supplies and equipment
 - 1 - Specially constructed target (Homasote faced), Homasote Company, Lower Ferry Road, Trenton, N.J.
 - 1 - Dry Ice Freezer Unit
 - 1 - Rochester Thermometer
 - 1 - Plywood Anthropometric Silhouette Target based on 1960 Dreyfus data
 - 1 - Dwyer Wind Meter (F.W. Dwyer Mfg. Co., Michigan City, Indiana)

APPENDIX D

STER. NO. 1 2 3 4 5 6

100 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400 3600 3800 4000 4200 4400 4600 4800 5000 5200 5400 5600 5800 6000 6200 6400 6600 6800 7000 7200 7400 7600 7800 8000 8200 8400 8600 8800 9000 9200 9400 9600 9800 10000 10200 10400 10600 10800 11000 11200 11400 11600 11800 12000 12200 12400 12600 12800 13000 13200 13400 13600 13800 14000 14200 14400 14600 14800 15000 15200 15400 15600 15800 16000 16200 16400 16600 16800 17000 17200 17400 17600 17800 18000 18200 18400 18600 18800 19000 19200 19400 19600 19800 20000 20200 20400 20600 20800 21000 21200 21400 21600 21800 22000 22200 22400 22600 22800 23000 23200 23400 23600 23800 24000 24200 24400 24600 24800 25000 25200 25400 25600 25800 26000 26200 26400 26600 26800 27000 27200 27400 27600 27800 28000 28200 28400 28600 28800 29000 29200 29400 29600 29800 30000 30200 30400 30600 30800 31000 31200 31400 31600 31800 32000 32200 32400 32600 32800 33000 33200 33400 33600 33800 34000 34200 34400 34600 34800 35000 35200 35400 35600 35800 36000 36200 36400 36600 36800 37000 37200 37400 37600 37800 38000 38200 38400 38600 38800 39000 39200 39400 39600 39800 40000

1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000 17000 18000 19000 20000 21000 22000 23000 24000 25000 26000 27000 28000 29000 30000 31000 32000 33000 34000 35000 36000 37000 38000 39000 40000

Figure 1. Recovered Components from a 40mm Liquid Round.

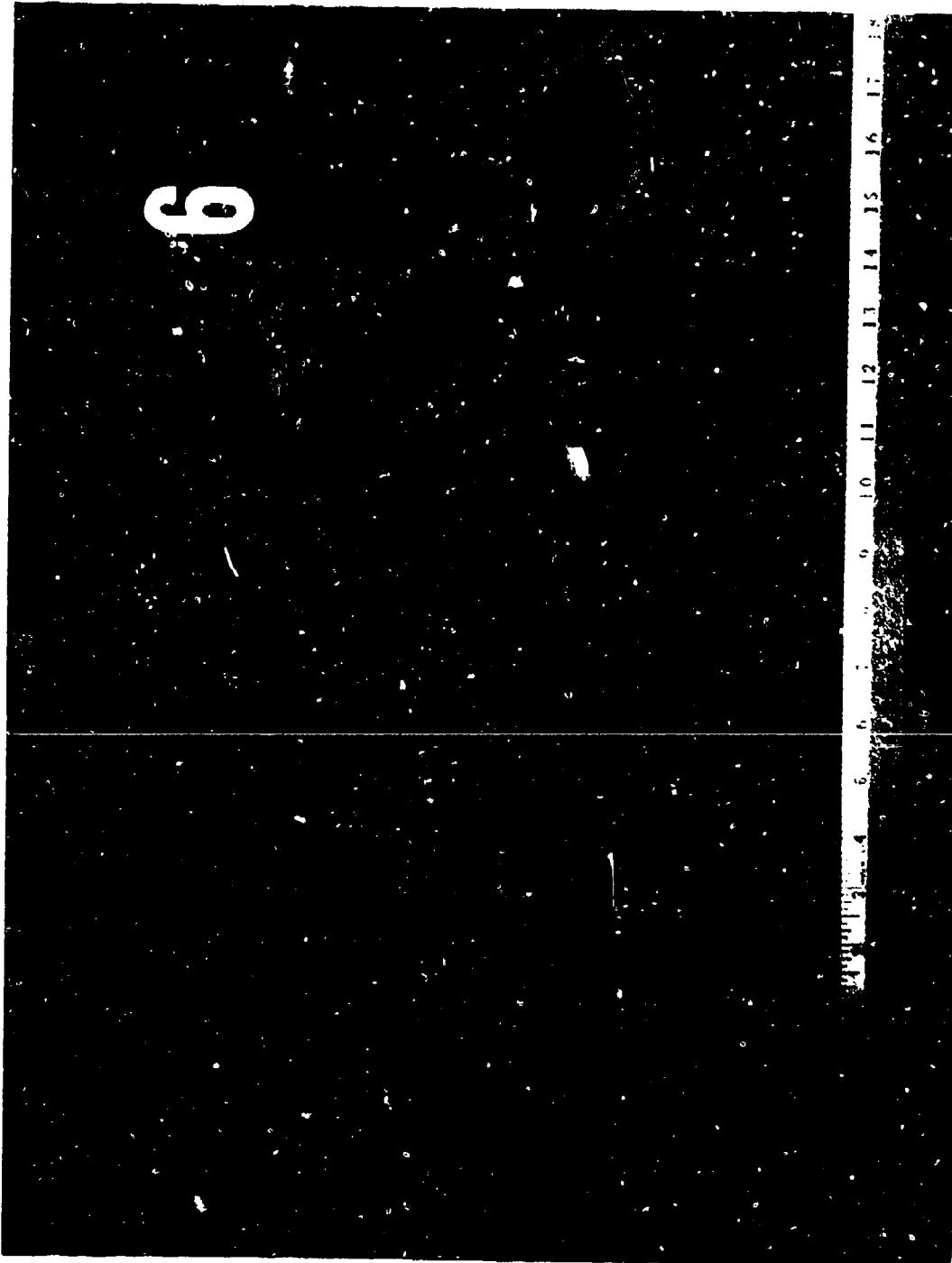


Figure 2. Round Number 27. Microflash, 40mm Liquid Ball Round.

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Figure 3. Round Number 28. Microflash, 40mm Liquid Ball Round.

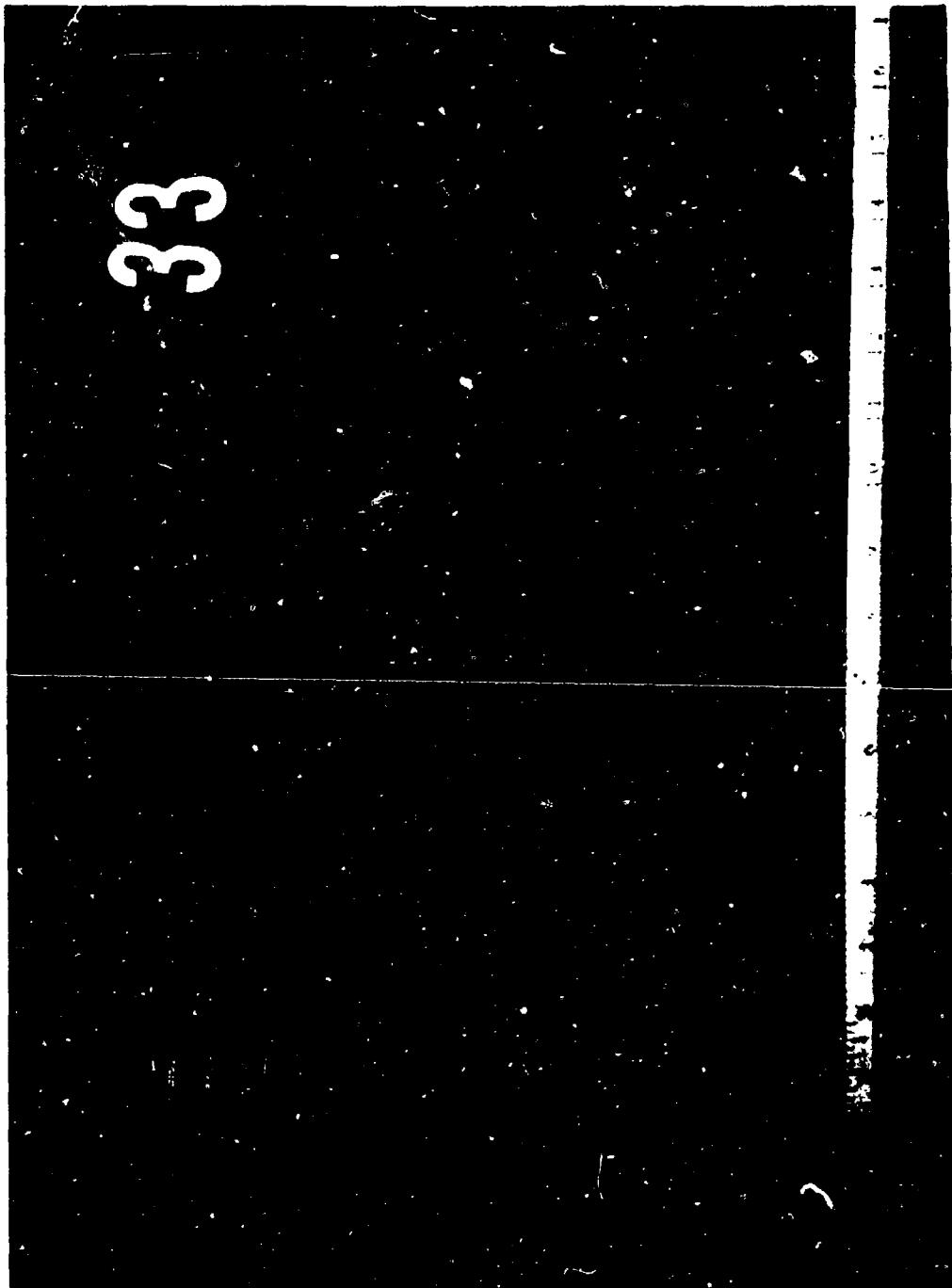


Figure 4. Round Number 29. Microflash, 40mm Liquid Ball Round.

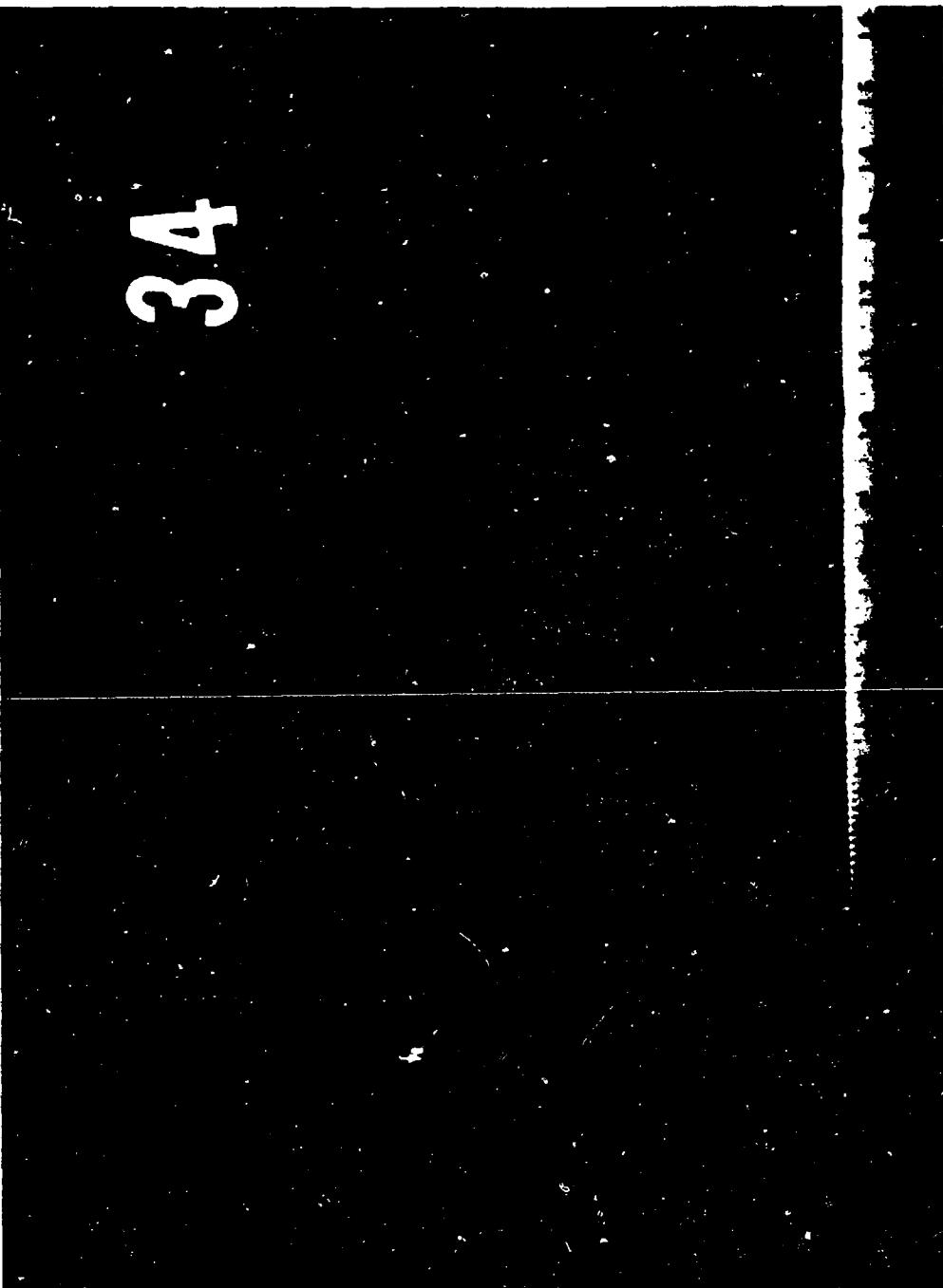


Figure 5. Round Number 30. Microflash, 40mm Liquid Ball Round.



Figure 6. Round Number 8. Photo of Broken Sabot.

APPENDIX E

12-Gauge Liquid Ball

(Test Firing)

TEST REPORT
LESS LETHAL 12-GAUGE LIQUID BALL - I

(TASK 02-E-73, CONTRACT
NO. DAAD05-73-C-0532
WORK ORDER NO. 12)

Prepared For

United States Army
Land Warfare Laboratory
Aberdeen Proving Ground, Maryland

By

H.P. White Laboratory
Bel Air, Maryland

February 1974

ABSTRACT

This report presents the results of initial tests of less lethal 12-Gauge Liquid Ball munitions in accordance with the provisions of Contract No. DAAD05-73-C-0532, Task 02-F-73 (an agreement between the U.S. Army Land Warfare Laboratory and H.P. White Laboratory).

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SECTION I. SCOPE OF WORK

1. OBJECTIVE

The objective of these tests was to provide the external ballistic data necessary to assess the ballistic performance of the "Nelson Marking Pellet" when fired from a 12 Gauge M1200 riot gun and also from a CO₂ powered Marking Pistol.

2. MATERIALS

The following materials were used in the conduct of this test program:

- a) 12 Gauge Liquid Ball (Nelson Marking Pellets) less lethal projectiles (see Figure 1).
- b) 12 gauge shot shell cases specially loaded.
- c) M1200 12 Gauge riot gun (Serial No. L571489).
- d) "Nel-Spot 007" CO₂ pistol and CO₂ power charges. (See Figure 2)
- e) Miscellaneous range and photographic equipment (see Appendix C).

3. SCOPE OF TESTS

Eighteen (18) rounds of 12 Gauge Liquid Ball ammunition were fired on an instrumented indoor range to determine velocity, accuracy, muzzle exit phenomena, and impact characteristics.

Forty-five (45) "Nelson Marking Pellets" were fired from a "Nel-Spot 007" marking pistol (CO₂) on an instrumented indoor range to determine velocity, accuracy, muzzle exit phenomena, impact characteristics, and the effect of shooter stress on accuracy. Ten rounds were fired on an outdoor range to determine maximum range and maximum effective hitting range when the projectiles are subject to environmental variables such as wind. Three (3) rounds were tested to determine the effect of cold temperature. (see Table I)

TABLE I. SCOPE OF TESTS

Round No.	Velocity		Energy			Impact Coordinates		Muzzle Exit Phenomena	Weapon	Cold Test	Maximum Effective Hit Range	Shooter Stress
	Muzzle	2m	5m	Muzzle	2m	5m						
1-15	LS	LS		C	C	A	A	MF	12 gauge shotgun			
16	HS			C			A	HS	12 gauge			
17-18	HS			C			A	HS	12 gauge			
19-39	HS	LS	LS	C	C	A	A	CO ₂ pistol	CO ₂ pistol			
40-41	HS			C			A	MF	CO ₂ pistol			
42-45							A	MF	CO ₂ pistol			
46-60							A	MF	CO ₂ pistol			
61-63							A	MF	CO ₂ pistol			
64-70							A	MF	CO ₂ pistol			
71-73							A	MF	CO ₂ pistol			

HS - High Speed Motion Picture
 LS - Lumiline Screens/Time Interval Counter
 MF - Micro Flash
 C - Calculated
 A - Measured
 T - Timed
 E - Estimated

SECTION II. PROCEDURE

1. VELOCITY

- a) The velocity of fifteen (15) rounds of the 12 Gauge Liquid Ball ammunition fired from an M1200 riot gun and twenty-one (21) Nel-Spot Marking Pellets fired from a "Nel-Spot 007" pistol was derived from data collected by erecting lumiline screens 5.06, 8.06, 14.9 and 17.9 feet (1.54, 2.46, 4.54, and 5.46 meters respectively) from the muzzle of the prone/rest fired test weapon. The outputs of these screens activated time interval counters from which the velocities at 2 and 5 meters from the muzzle were calculated.
- b) Velocity of two (2) each of the 12 Gauge Liquid Ball and Nel-Spot Marking Pellets was calculated from data extracted from high speed motion pictures of the muzzle and initial few feet of projectile flight recorded by 16mm Eastax motion picture cameras positioned 4 feet 8 inches to the right of the line of fire and 9 inches in front of the muzzle. The film speed, used to compute the projectile velocity, was determined from timing marks on the film created by a time pulse generator.

2. PROJECTILE ENERGY

Projectile energy was calculated by applying the unfired projectile weight and the velocity data derived per 1, above, to the standard energy formula--

$$\text{Kinetic Energy} = (1/2) MV^2$$

3. ACCURACY

The accuracy of the 12 Gauge Liquid Ball ammunition was determined from impact data on a target constructed of 2" x 1" wood backing, 1/2-inch thick Homasote and faced with paper. The accuracy of the ammunition was determined by measuring the horizontal and vertical dispersion from the aiming point on the target. Standard deviations in the x and y directions and the mean radius were calculated.

4. IMPACT CHARACTERISTICS

Indentations in the Homasote, produced by each projectile impact, were measured using a depth micrometer and the average indentation was calculated. Indications of projectile attitude at impact were observed and noted. These data were collected from the target when positioned 6.4, 20, 35, and 50 meters from the muzzle of the prone/rest fired test weapon.

5. EFFECT OF SHOOTER STRESS ON ACCURACY

Three (3) shooters fired five (5) "Ne1 Spot Marking Pellets" each at an anthropometric silhouette target positioned 35 meters from the shooter. In order to induce stress, each shooter was told that he would have an average of 4 seconds (varying from 3 seconds to 5 seconds) to raise the pistol, sight and fire at the target. This timing was accomplished by utilizing a cardboard shield which obscured the shooter's view of the target before and after each shot. No warning was given before the shield was raised and the time interval started. The coordinates of each shot in relation to the center of the chest area of the silhouette were recorded. Whether or not a hit had been scored on the man-size silhouette was recorded and any hits in critical areas (groin and eyes) were noted. Standard deviation in the x and y directions and the mean radius were calculated from these data.

6. MAXIMUM RANGE

The "Ne1-Spot 007" Gas Pistol with its barrel elevated 30° from horizontal, was fired from a bench rest on a 400-meter outdoor range. After each shot, the distance the projectile traveled before its initial impact with the ground was measured as well as the deflection right or left of the line of sight.

7. MAXIMUM EFFECTIVE HITTING RANGE

The "Ne1-Spot 007" Gas Pistol was bench rest fired at an anthropometric silhouette target positioned 35 meters from the muzzle. After three (3) firings without scoring a hit on the silhouette, the target was moved to 20 meters from the muzzle for the remaining four (4) firings. Wind velocity at each firing was measured using a Dwyer "Wind Meter." Silhouette target hits and misses, impact coordinates, and flight time from muzzle to target (timed by stop watch) were recorded. Estimate maximum effective hitting range was the average of three (3) observers opinion of range at which tactical hits could be expected under test conditions.

8. COLD TEMPERATURE FIRING

Three (3) of the "Ne1-Spot Marking Pellets" were stored at -45°F for 24 hours. They were then stored for one additional hour at 0°F before being loaded into the machine rest mounted "Ne1-Spot 007" CO₂ pistol. It was planned that each shot was to be remotely fire and that impact coordinates and the indentation in the "Homasote" faced target were to be measured and recorded. This procedure was altered during testing. (See SECTION II, RESULTS)

9. MUZZLE EXIT PHENOMENA

Three (3) 12 Gauge Liquid Balls were photographed as they exited the muzzle of the M1200 riot gun. Two (2) rounds were photographed using two (2) 16mm Fastax High Speed Motion Picture cameras simultaneously. One Fastax camera was positioned perpendicular to and 4 feet 8 inches from the line of fire, 9 inches forward of the muzzle. The other Fastax camera was positioned 38.3 feet forward of the muzzle, 3 feet to the left of the line of fire and focused on the muzzle. Both cameras ran at a nominal 4000 frames per second. The third round was photographed using a Linhof 4" x 5" camera positioned 4 feet to the right and 1 foot in front of the muzzle. Four (4) General Radio "Stroboslave" recycling flash units were pulsed at .0013 second intervals for a flash duration of .000005 seconds each. These strobes provided four (4) exposures of the projectile within 17 inches of the muzzle. Six (6) "Ne1-Spot Marking Pellets" were photographed as they exited the muzzle of the "Ne1-Spot 007" CO₂ pistol. Two (2) rounds were photographed using the 16mm Fastax equipment as described above. Four (4) rounds were photographed using the recycling flash units described above. Projectile muzzle exit was studied by examining the 16mm high speed motion picture film and enlargements of the 4" x 5" microflash photography (See Figures 3 thru 7).

10. SAFETY

Normal safety procedures were used during the conduct of these tests.

SECTION III. RESULTS

1. VELOCITY

Table II is a summary of the velocity data contained on the data sheets of Appendix A.

TABLE II. RESULTS OF VELOCITY TESTS (f.p.s.)
12-Gauge Liquid Ball

12 Gauge Liquid Ball, (Ne1-Spot Marking Pellets) <u>M1200 12 Gauge Riot Gun</u>			
	Muzzle** (2 rds)	2m* (15 rds)	5m* (13 rds)
Maximum	471.5	404.9	351.6
Minimum	390.5	271.6	157.0
Average	451.0	352.8	276.3
 Ne1-Spot Marking Pellets <u>Ne1-Spot 007 CO₂ Pistol</u>			
	Muzzle** (2 rds)	2m* (21 rds)	5m* (21 rds)
Maximum	356.5	288.9	265.8
Minimum	335.8	244.4	226.4
Average	346.2	260.1	240.8

*Lumiline screens/time interval counter
(accuracy \pm 3 f.p.s.)

**High Speed Motion Pictures
(accuracy \pm 20 f.p.s.)

2. PROJECTILE ENERGY

Table III is a summary of calculations based on the data contained in Appendix A.

TABLE III. PROJECTILE ENERGY (ft-lbs)
12 Gauge Liquid Ball

12 Gauge Liquid Ball (Nel-Spot)/12 Gauge Shotgun			
	Muzzle (2 rds)	2m (15 rds)	5m (13 rds)
Maximum	20.3	15.0	11.3
Minimum	14.0	6.8	2.3
Average	17.2	11.5	7.5
<u>Nel-Spot Marking Pellets (Nel-Spot 007 Co₂ Pistol)</u>			
	Muzzle (2 rds)	2m (21 rds)	5m (21 rds)
Maximum	11.6	7.6	6.5
Minimum	10.3	5.5	4.7
Average	11.0	6.2	5.3

3. ACCURACY

Table IV is a summary of calculations based on the data contained in Appendix A.

TABLE IV. RESULTS OF ACCURACY TESTS
12 Gauge Liquid Ball

Target Distance (meters)	Group Center (from point of aim)		Extreme Spread (in.)		Standard Deviation (in.)		Mean Radius (in.)							
	x	y	x	y	x	y								
<u>12 Gauge Liquid Ball (Ne1-Spot Marking Pellets)</u>														
<u>M1200 12 Gauge Riot Gun</u>														
6.4	+0.4	+0.2	12.3	13.8	4.2	5.1	5.4							
20	Projectiles broke in flight. 2 of 7 reached target.													
<u>Ne1-Spot Marking Pellet</u>														
<u>Ne1-Spot 007 CO₂ Pistol</u>														
6.4	-1.2	+0.9	9.2	6.2	2.9	2.3	2.9							
20	-5.4	+5.7	14.0	40.7	6.1	14.2	12.8							
55	-22.7	-5.1	47.5	54.7	13.2	19.8	19.5							

4. IMPACT CHARACTERISTICS

None of the 12 Gauge Liquid Balls or Ne1-Spot Marking Pellets produced a measurable impact on the Homasote faced target.

5. EFFECT OF SHOOTER STRESS ON ACCURACY

Table V is a summary of the calculations based on the data contained in Appendix A.

TABLE V. SUMMARY OF STRESS TEST RESULTS
Nel-Spot Marking Pellets - Nel-Spot 007 CO₂ Pistol

Shooter	Group Center (from point of aim) (in.)		Extreme Spread (in.)		Standard Deviation (in.)		Mean Radius (in.)	Total Hits on Silhouette	Hits in Critical Area
	x	y	x	y	x	y			
A	+10.1	-33.4	22.1	12.6	8.3	4.9	7.1	1	0
B	+22.1	-13.3	51.8	30.7	19.2	12.7	19.1	1	0
C	-24.2	-29.1	29.9	31.0	12.7	11.3	14.5	0	0

6. MAXIMUM RANGE

Table VI is a summary of the data contained in Appendix A.

TABLE VI MAXIMUM RANGE
Nel-Spot Marking Pellets -
Nel-Spot 007 CO₂ Pistol

	Distance (meters)	Deflection (meters)
Maximum	67.0	21.0-right
Minimum	62.0	4.0-right
Average	64.7	12.5-right

7. MAXIMUM EFFECTIVE HITTING RANGE

Table VII is a summary of the data contained in Appendix A.

TABLE VII MAXIMUM EFFECTIVE HITTING RANGE
Nel-Spot Marking Pellets - Nel-Spot 007 CO₂ Pistol

Impact Coordinates (in.)		Wind Velocity (m.p.h.)	Average Flight Time (sec.)	Remarks
x	y			
TARGET DISTANCE 35 METERS (3 ROUNDS)				
-70.5	-31.0	0	9.0-9.5	0.8* 2 projectiles impacted ground at 25 and 30 meters.
TARGET DISTANCE 20 METERS (4 ROUNDS)				
-7.9**	-1.6**	1	10.0-11.5	0.5** 1 projectile broke in bore at firing

*One round only.
**Three rounds only.

It was the opinion of the three (3) observers that the maximum range at which tactical hits on a man could be expected was approximately 10 meters.

8. COLD TEMPERATURE FIRING

The Nel-Spot Marking Pellets expanded during the cold storage conditioning so that they would fit into the magazine of the Nel-Spot 007 CO₂ pistol but would not enter the chamber. No shots could be fired.

9. MUZZLE EXIT PHENOMENA

The muzzle exit of three (3) rounds of 12 Gauge Liquid Ball was recorded photographically--two (2) with 16mm high speed motion pictures and one (1) with recycling microflash. Analysis of the film revealed:

- a) Round No. 17 shows projectile filler (paint) exiting projectile beginning approximately 10 inches from muzzle.

- b) Round No. 18 shows gas exiting the muzzle before the projectile and projectile spilling filler (paint).
- c) Round No. 16 (microflash) shows projectile filler (paint) exiting projectile. (See Figure 3)

The muzzle exit of six (6) rounds of Nel-Spot Marking Pellets was recorded photographically--two (2) with 16mm high speed motion pictures and four (4) with recycling microflash.

- a) Round 40 projectile obscured in gas (CO_2) during first 8 inches of flight--no abnormalities observed.
- b) Round 41 shows gas (CO_2) exiting muzzle before projectile--no other abnormalities.
- c) Rounds No. 38, 39, and 40 the projectile is obscured by gas (CO_2) for approximately 16 inches of flight.
- d) Round No. 20 is obscured by gas (CO_2) for approximately 20 inches.

APPENDIX A

Date 19 October 1975
 Temperature 52°F; Humidity 64%
 2-Meter Screens 5.00' and 8.06' (over 5')
 5-Meter Screens 14.90' and 17.90' (over 5')

Shooter Poole
 Recorder Sunwalt
 Chronograph Whicht
 Chronograph E.C.
 Ammunition 12 Ga. Liquid Ball
 Type -- Lot --
 Target 6.4 meters

Shot No.	2-Meter			5-Meter			Coordinates			Aiming Data		Indent. in aluminum (in.)	Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt. (grn.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (grn.)	X (in.)	Y (in.)	Z (in.)	Level	23 1/4"		
1 08987	3335.8	41.2	1401.7	214.0	41.2	+4.0	+4.9	Level	23 1/4"			0	Projectile appeared to break at first screen. Base wad found between first and second and was covered with paint
2 09429	318.1	41.2	15538	224.9	41.2	+2.0	+0.5	Level	23 1/4"			0	Projectile broke in barrel
3 07482	401.0	41.2	09526	321.7	41.2	-0.9	+7.5	Level	23 1/4"			0	
4 09935	502.0	41.2	12554	258.9	41.2	+5.4	-2.0	Level	23 1/4"			0	Broke in flight
5 07410	404.9	41.2	14451	209.1	41.2	-2.7	-6.3	Level	23 1/4"			0	Broke in flight
6 08621	574.5	41.2	08783	341.5	41.2	+0.5	-5.2	Level	23 1/4"			0	Broke in flight
7 09040	331.9	41.2	10136	295.9	41.2			Level	23 1/4"			0	Broke in flight.
8 07758	386.7	41.2	08547	351.0	41.2	+0.4	+0.2	Level	23 1/4"			0	Hit second screen shield
													Broke in flight
													Heavy deposits of unburned powder found in barrel after each shot.
													*Average weight.

Date 23 October 1973
 Temperature 60°F ; Humidity 65%
 2-Meter Screens 5.06' and 8.06' (over 3')
 5-Meter Screens 14.90' and 17.90' (over 3')

Shooter Poole
 Recorder Simkait
 Chronograph E.C.
 Chronograph Oehler
 Type --
 Target 20

S-Meter S-Meter

Shot No.	2-Meter		S-Meter		Coordinates		Aiming Data	Indent in Homasote (in.)	Results	
	Time (sec)	Vel. (ft/sec)	Proj. Wt.* (gn.)	Time (sec)	Vel. (ft/sec)	Wt. (gn.)	X (in.)	Y (in.)		
9	11045	271.6	41.2	13999	214.3	41.2		Level 23 1/4"	0	Round broke in flight and never reached target.
10	08257	364.2	41.2	10011	299.6	41.2		Level 23 1/4"	0	Round broke in flight and never reached target.
11	08070	371.7	41.2	08870	338.2	41.2	+15.8	-2.3	0	Round broke in flight and never reached target.
12	08251	363.6	41.2	10274	292.0	41.2		Level 23 1/4"	0	Round broke in flight and never reached target.
13	08097	370.5	41.2	09487	316.2	41.2		Level 23 1/4"	0	Round broke in flight and never reached target.
14	08742	343.2	41.2	19106	157.0	41.2		Level 23 1/4"	0	Round broke in flight and never reached target.
15	08483	353.6	41.2	13869	210.3	41.2	+50.7	-5.7	0	Round broke in flight and never reached target.

*Average weight.

Date 26 October 1973 Shooter Poole Job No. 1883-12
 Temperature 54°F; Humidity 70% Recorder Sunwalt Page
 2-Meter Screens and (over) Chronograph
 5-Meter Screens and (over) Chronograph
 Type Lot
 Target 50 meters

Shot No.	2-Meter Time (sec)	S-Meter Vel. (ft/sec)	Proj. Wt. (gm.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gm.)	Coordinates		Aiming Data	Incident in Homasote (in.)	Results
							x (in.)	y (in.)			
16	Micro Flash						-	-	Level 23 1/4"	-	Could not find point of impact on target
17	16mm Black and White	High Speed Movies					-	-	Level 23 1/4"	-	Could not find point of impact on target.
				29 October 1973					54°F 75% R.H.		
18	16mm Color High Speed	Movies					-	-		-	Could find no indication of impact on target.

Date 8 November 1973

Job No. 1883-12

Temperature 52°F; Humidity 65%
 2-Meter Screens 5.06' and 8.06' (over 3')
 5-Meter Screens 14.90' and 17.90' (over 3')

Shooter Poole
 Recorder Sunkult
 Chronograph L.C.
 Chronograph Behler

Page _____
 Weapon M.I.-SRV 007
 Ammunition Nelson Marking Pellets
 Type -- Lot 2636
 Target 5.4 meters

Shot No.	Time (sec)	2-Meter Vel. (ft/sec)	Proj. Wt. (gr.)	S-Meter Time (sec)	Vel. (ft/sec)	Proj. Wt.* (gr.)	Coordinates			Aiming Data	Indent. In Minnesota (in.)	Results
							x (in.)	y (in.)	z (in.)			
19	11892	252.5	41.2	12839	252.5	41.2	-6.4	-2.4	Level 23 1/4"	"	Paint ball broke on impact.	
20	11510	260.6	41.2	12461	249.7	41.2	-1.4	+2.6	level 23 1/4"	0	Paint ball broke on impact.	
21	11589	258.9	41.2	12571	238.6	41.2	+1.1	+0.7	Level 25 1/4"	0	Paint ball broke on impact.	
22	11560	259.5	41.2	12515	259.7	41.2	-0.3	+1.0	Level 23 1/4"	0	Paint ball broke on impact.	
23	11720	256.0	41.2	12656	237.4	41.2	+2.8	-1.7	Level 23 1/4"	0	Paint ball broke on impact.	
24	12243	245.0	41.2	13157	228.0	41.2	-1.9	+3.8	Level 25 1/4"	0	Paint ball broke on impact.	
25	11215	267.5	41.2	12107	247.7	41.2	-2.2	+2.5	Level 23 1/4"	0	Paint ball broke on impact.	
One CO ₂ cylinder used for entire test.												

*Average weight.

Date 8 November 1973

Temperature 52°F; Humidity 65%

2-Meter Screens 5.06' and 8.06' (over 5')

5-Meter Screens 14.90' and 17.90' (over 5')

Shooter Poole

Recorder Simultaneous

Chronograph E.C.

Chronograph Oehler

Job No. 1883-12

Page 1 of 1

Weapon M.L-SPOI 007

Ammunition Nelson Marking Pellet

Type -

Target 20 meters

Shot No.	2-Meter			5-Meter			Coordinates			Aiming Data		Indent. in. from nose (in.)	Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt.* (grn.)	Time (sec)	Vel. (ft/sec.)	Proj. Wt. (grn.)	x (in.)	y (in.)	z (in.)	Level	23 1/4"		
26	10385	288.9	41.2	11287	265.8	41.2	-9.1	-25.0		Level	23 1/4"	0	Ball did break on impact.
27	11083	270.7	41.2	12050	249.3	41.2	-6.4	-5.6		Level	23 1/4"	0	Ball did break on impact.
28	10872	275.9	41.2	11784	254.5	41.2	+1.6	+10.2		Level	23 1/4"	0	Ball did not break on impact.
29	11173	268.5	41.2	12013	249.7	41.2	-0.9	+1.2		Level	23 1/4"	0	Ball did not break on impact.
30	11392	265.3	41.2	12307	245.7	41.2	+1.6	+11.0		Level	23 1/4"	0	Ball did not break on impact.
31	11398	263.2	41.2	12290	244.1	41.2	-11.8	+14.3		Level	23 1/4"	0	Ball did break on impact.
32	11719	256.0	41.2	12641	257.3	41.2	+12.4	+17.7		Level	23 1/4"	0	Ball did break on impact.

*Average weight.

Date 8 November 1973

Temperature 49°F; Humidity 65%

2-Meter Screens 5.06' and 8.06' (over 3')
5-Meter Screens 14.90' and 17.90' (over 3')

Shooter Poole

Recorder Samwalt

Chronograph F.C.

Chronograph Oehler

Type --

Lot --

Target 35 meters

Job No. 1883-12	Page 1 of 1
Weapon NL-SPT 007	
Ammunition Nelson Marking Pellet	
Type --	
Target 35 meters	

Shot No.	Time (sec.)	Vel. (ft/sec.)	Proj. Wt.* (gm.)	S-Meter Time (sec.)	Vel. (ft/sec.)	Proj. Wt.** (gm.)	Coordinates			Aiming Data	Indent. in Tomosote (in.)	Results
							x (in.)	y (in.)	z (in.)			
33	12121	247.5	41.2	13016	230.4	41.2	-39.0	-9.7	-vel 23 1/4"		0	Ball broke on impact.
34	11947	251.1	41.2	12852	233.4	41.2	-17.8	-15.4	Level 23 1/4"		0	Ball did not break on impact.
35 *	11620	258.2	41.2	12548	239.0	41.2	-43.7	+7.1	Level 23 1/4"		0	Ball did not break on impact.
36 *	11452	262.0	41.2	12345	243.0	41.2	-15.8	-15.9	Level 23 1/4"		0	Ball broke on impact.
37 *	12276	244.4	41.2	13248	226.4	41.2	-16.9	-16.6	Level 23 1/4"		0	Ball did not break on impact
38 *	11736	255.6	41.2	12635	257.4	41.2	-17.0	-19.8	Level 23 1/4"		0	Ball broke on impact. It appeared to hit floor prior to impacting target.
39 *	11703	256.3	41.2	12647	237.2	41.2	-8.5	+34.9	Level 23 1/4"		0	Ball did not break on impact.
*Lipstick used to find impact point. **New CO ₂ cylinder used. ***Average weight.												

Date 26 October 1975
 Temperature 54°F; humidity 70%
 Spotter Screens - and - (over ---)
 Spotter Screens - and - (over ---)

Shooter Poole
 Recorder Sunwalt
 Chronograph ---
 Chronograph ---

Type ---
 Target 50 meters

Sighter	Proj.	S-Meter	Proj.	Coordinates	Aiming Data	Indent. in Housote (in.)	Results
Sight Time s., (sec.)	Vel. ft/sec.)	Run wt. (gm.)	Proj. vel. (sec.)	X (in.)	Y (in.)	-	Could not find point of impact on target.
40 16mm Black and White High Speed Movies				-	- Level 25 1/4"	-	
41 16mm Color High Speed Movies				-	- Level 25 1/4"	-	Could not find point of impact on target.

Date 31 October 1973

Temperature 50°F; Humidity 67%

Recorder Sunwalt

Page

Weapon NL-SROT 007

2-Meter Screens --- and --- (over ---)
 5-Meter Screens --- and --- (over ---)

Ammunition Nelson Super Spot Marking Pellets
 Type --- Lot ---
 Target 50 meters

	Shooter Poole	Recorder Sunwalt	Page	Job No. 1883-12						
2-Meter	5-Meter	Coordinates	Aiming Data	Results						
Shot No.	Time (sec.)	Proj. Wt. (gr.)	Vel. (ft/sec.)	Time (sec.)	Proj. Wt. (gr.)	Vel. (ft/sec.)	Time (sec.)	x (in.)	y (in.)	Indent. in. Ionomasote (in.)
42	Micro Flash						-	-	Level 23 1/4"	-
				1 November	1973	54°F	66% R.H.			Could find no indication of impact.
43	Micro Flash						-	-	Level 23 1/4"	-
44	Micro Flash						-	-	Level 23 1/4"	-
45	Micro Flash						-	-	Level 23 1/4"	-

2-Meter	5-Meter	Coordinates	Aiming Data	Results						
Shot No.	Time (sec.)	Proj. Wt. (gr.)	Vel. (ft/sec.)	Time (sec.)	Proj. Wt. (gr.)	Vel. (ft/sec.)	Time (sec.)	x (in.)	y (in.)	Indent. in. Ionomasote (in.)
42	Micro Flash						-	-	Level 23 1/4"	-
				1 November	1973	54°F	66% R.H.			Could find no indication of impact.
43	Micro Flash						-	-	Level 23 1/4"	-
44	Micro Flash						-	-	Level 23 1/4"	-
45	Micro Flash						-	-	Level 23 1/4"	-

Date	23 November 1973	Shooter	Pooler - "AA"	Job No.	1883-12
Temperature	57°F; Humidity 66%	Recorder	Flohr	Page	_____
2-Meter Screens	... and ... (over ...)	Chronograph	...	Weapon	N.I.-SPOT 007
5-Meter Screens	... and ... (over ...)	Chronograph	...	Ammunition	Nelson Super Spot Marking Pellet
Type	---	Lot	---	Target	35 meters

Shot No.	Time (sec)	2-Meter Vel. (ft/sec)	S-Meter Proj. Wt. (gn.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)	Coordinates x (in.)	Coordinates y (in.)	Aiming Data	Indent. in. Homasote (in.)	Results
							46	47	48	49	50
46							+7.0	-36.0	Mass		Missed
47							+11.2	-33.4	Mass		Missed
48							+23.7	-27.5	Mass		Missed
49							+7.0	-30.1	Mass		Missed
50							+1.6	-40.1	Mass		Hit

Date 23 November 1973
 Temperature 57°F; Humidity 56%
 2-Meter Screens --- and --- (over ---)
 5-Meter Screens --- and --- (over ---)

Job No. 1385-12

Re-order Sumwalt
 Page ---
 Weapon NEL-SIGHT 007
 Ammunition Nelson Super Spot Marking Project
 Type ---
 Lot ---
 Target 35 meters

TIMED FIRE:

Shot No.	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)	Coordinates			Aiming Data	Indent. in. Homasote (in.)	Results
							S-meter	X (in.)	Y (in.)			
51								-1.8	+2.2	Mass		Hit
52								+24.0	-28.5	Mass		Missed
53								+50.0	-12.0	Mass		Missed. Did not break.
54								+26.3	-23.4	Mass		Missed
55								+12.0	-5.0	Mass		Missed

Date 23 November 1973

Temperature 57°F ; Humidity, 66%

2-Meter Screens --- and --- (over ---)
 5-Meter Screens --- and --- (over ---)

Job No. 1883-12

Page

Weapon Mil-Spec 007

Ammunition Nelson Super Spot Marking Pellet
 Type ---
 Target 35 meters

TIMED FIRE

Shot No.	2-Meter			5-Meter			Proj. Wt. (gn.)	Wt. (ft/sec)	Time (sec)	Vel. (ft/sec)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)	Coordinates			Aiming Data	Indent. in Tomasots (in.)	Results
	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)	Time (sec)	Vel. (ft/sec)	Proj. Wt. (gn.)								x (in.)	y (in.)	z (in.)			
56														-13.5	-11.1	Mass			Missed
57														-13.6	-30.1	Mass			Missed
58														-43.4	-29.3	Mass			Missed
59														-20.3	-42.1	Mass			Missed
60														-30.1	-32.7	Mass			Missed

OBSERVED DATA

MAXIMUM RANGE

Nel-Spot Marking Pellets - Nel-Spot 007 CO₂ Pistol
Barrel Elevated 30°

Date: 5 February 1974

Temperature: 30°F, variable
cross wind (left to right)

Round No.	Range (meters)	Deflection (meters)	Remarks
61	62.0	4.0-right	Did not break on impact with ground.
62	65.0	12.0-right	Did not break on impact with ground.
63	67.0	21.0-right	Did not break on impact with ground.

OBSERVED DATA

MAXIMUM EFFECTIVE HITTING RANGE

Nel-Spot Marking Pellets - Nel-Spot 007 CO₂ Pistol

Date: 1 March 1974

Temperature: 45°F, variable cross wind
right to left

Round No.	Impact Coordinates (in.) x y		Silhouette Hit/ Missed	Wind Velocity (m.p.h.)	Flight Time (sec.)	Remarks
			TARGET	DISTANCE 35 METERS		
64	-70.5	-31.0	Missed	9.0	0.8	
65	-	-	Missed	9.5	-	Hit ground at 25m.
66	-	-	Missed	9.0	-	Hit ground at 23m.
			TARGET	DISTANCE 20 METERS		
67	-13.5	+29.7	Missed	10.0	0.5	
68	-18.7	-22.4	Missed	10.0	0.5	
69	+8.6	-12.0	Hit	11.0	0.4	
70	-	-	Missed	11.5	-	Broke in barrel.

OBSERVED DATA

COLD TEST

Nel-Spot Marking Pellets - Nel-Spot 007 CO₂ Pistol

Date: 12 February 1974

Ammunition: Stored at -45°F for 24 hours.
Stored at 0°F for 1 hour immediately before firing.

Machine rest, lanyard fired

Target: 35 meters

Aiming point: 47 1/2 inches high

Round No.	x (in.)	y (in.)	Indentation (in.)	Remarks
71	-	-		
72	-	-		
73	-	-		Paint balls, when subjected to cold temperature, expanded and would not fit into the bore of the pistol.

APPENDIX B

CALCULATED DATA

ACCURACY
12 Gauge Liquid Ball
6.4 Meters

CALCULATED DATA

ACCURACY

Nelson Marking Pellet
6.4 Meters

Round No.	Coordinates (in.)		Calculations		Radius (in.)
	x	y	(x - x)	(y - y)	
19	- 6.4	- 2.4	27.04	10.89	6.2
20	1.4	+ 2.6	0.04	2.89	1.7
21	+1.1	+ 0.7	5.29	0.04	2.3
22	-0.3	+ 1.0	0.81	0.01	0.9
23	+2.8	- 1.7	16.00	6.76	4.8
24	-1.9	+3.8	0.49	8.41	3.0
25	-2.2	+2.3	1.00	1.96	1.7
<hr/>					
Standard Deviation			x (in.)	y (in.)	---
	---		2.9	2.3	
	---		---	---	
Mean	$\bar{x} = +1.2$	$\bar{y} = +0.9$	---	---	2.9
Extreme Spread	9.2	6.2	---	---	---

CALCULATED DATA

ACCURACY

Nelson Marking Pellet
20 Meters

CALCULATED DATA

ACCURACY

Nelson Marking Pellet
35 Meters

CALCULATED DATA

ACCURACY
Timed Fire
Nelson Super Spot
Marking Pellet

CALCULATED DATA

ACCURACY
Timed Fire
Nelson Super Spot
Marking Pellet

Round No.	Coordinates (in.)		Calculations		Radius (in.)
	x	y	$(x - \bar{x})^2$	$(y - \bar{y})^2$	
51	+1.8	+2.2	571.21	240.25	28.5
52	+24.0	-28.5	3.61	251.04	15.3
53	+50.0	-12.0	778.41	1.69	27.9
54	+20.3	-23.4	17.64	102.01	10.9
55	+12.0	-5.0	102.01	68.89	13.1
<hr/>					
<hr/>					
<hr/>					
		x (in.)	y (in.)		
Standard Deviation	---	---	19.2	12.7	---
Mean	$\bar{x} = +22.1$	$\bar{y} = -13.5$	---	---	19.1
Extreme Spread	51.8	30.7	---	---	---

CALCULATED DATA

ACCURACY
Timed Fire
Nelson Super Spot
Marking Pellet

APPENDIX C

TEST INSTRUMENTATION
EQUIPMENT AND MATERIALS

- 1 - Oehler Model 41B Chronotach, calibrated at factory in May 1973
- 1 - Electronic Counters, Inc. Model 4010 Velocity Computing Chronograph, calibrated at factory in June 1973
- 4 - Oehler Model 35 Lumiline Screens
- 2 - Fustax 16mm High Speed Motion Picture Cameras
- 1 - Wollensak Model 3106 Time Pulse Generator
- 2 - Colortran 1000 Watt Lights
- 2 - Wollensak 1000 Watt Lights
- 4 - 100-foot Rolls Kodak Ektachrome (7242) 16mm High Speed Film (GFE)
- 4 - 100-foot Rolls Eastman Double-X Negative (722) 16mm High Speed Film
- 1 - Vanguard Model 16C Motion Analyzer
- 4 - General Radio Type 1539 "Stroboflash" Microflash
- 1 - General Radio Model 1541 Multi-Flash Generator
- 1 - Linhof 4x5 Camera with Kodak f1.5, 135mm Lens
- 6 - Royal Pan 4" x 5" Cut Film, Type 4141
 - Various darkroom and photographic equipment
 - 100-meter indoor range having ceiling height of 12 feet
 - 400-meter outdoor range
 - Miscellaneous range supplies and equipment
- 1 - Specially constructed target (Homasote faced), Homasote Company, Lower Ferry Road, Trenton, N.J.
- 1 - Dry Ice Freezer Unit
- 1 - Rochester Thermometer
- 1 - Plywood Anthropometric Silhouette Target based on 1960 Dreyfus data
- 1 - Dwyer Wind Meter, F.W. Dwyer Mfg Co., Michigan City, Indiana

APPENDIX D

NEL SPOT MARKING PELLETS
(BAND INDICATES COLOR)

FOR REMOTE MARKING OF ANIMALS, TREES, OR ALMOST ANYTHING. USE WITH NEL SPOT "602" OR "702" MARKING GUN. KEEPS THE COLORED END CAP FROM TUBE AND ROLL CONTAINER INTO MAGAZINE.

LIMITED STORAGE LIFE - KEEP COOL & DRY. AVOID FREEZING. FLAMMABLE. KEEP AWAY FROM CHILDREN -- HARMFUL IF EATEN.

CONTENTS: 12 - 14 UNIT TUBES
(168 NET COUNT) - MADE IN U.S.A.

BOLITAS MARCADORAS NEL-SPOT
(La franja indica el color)

PARA MARCAR A DISTANCIA ANIMALES, ARBOLES Y CASI TODA CLASE DE SUPERFICIES. USARSE CON LA PISTOLA NEL SPOT "602" O "702". QUITESE LA TAPA PINTADA E INSERTENSE LAS GOLITAS EN EL MAGAZIN.

DURACION DE ALMACENAJE LIMITADA — GUARDENSE EN UN LUGAR FRESCO SIN HUMEDAD. EVITE QUE SE CONGELEN. NO LAS ACERQUE AL FUEGO. MANTENGANSE ALEJADO DE LOS NIÑOS. PELIGROSO A COMER.

CONTENIDO: 12 CILINDROS CON 14 BOLITAS
CADA UNO (168 BOLITAS EN TOTAL)
PRODUCTO DE E.U.A.

PLOMBS MARQUEURS NEL-SPOT
(La bande indique la couleur)

POUR MARGUER A DISTANCE LES ANIMAUX, LES ARBRES ET LA PLUPART DES SURFACES. UTILISER AVEC LE PISTOLET A PLOMBS NEL SPOT "602" OU "702". ENLEVER LE COUVERCLE COLORE ET INTRODUIRE LES PLOMBS DANS LE MAGASIN DU PISTOLET.

EMMAGASINAGE LIMITÉ—CONSERVER DANS UN ENDROIT FRAIS ET SEC. EVITER LE GEL. NE PAS APPROCHER DU FEU. TENIR ÉLOIGNE DES ENFANTS—DANGEREUX A MANGER.

CONTENU: 12 TUBES AVEC 14 PLOMBS CHACUN
(TOTAL DE 168 PLOMBS)
FABRIQUE AUX ETATS-UNIS.

NEL SPOT MARKIERUNGSPLATZCHEN
(Der Streifen zeigt die Farbe an)

MIT DER NEL SPOT "602" ODER "702" MARKIERUNGSPISTOLE ZUM FERNMARKIEREN VON TIERN, BAUMEN, UND DIE MEISTEN OBERFLÄCHEN ZU GEBRAUCHEN. DEN GEFAHRBAREN DECKEL AUFZUHÖLEN UND DIE PLATZCHEN INS MAGAZIN EINZUSETZEN.

BEGRENZTE LAGERZEIT -- KÜHL UND TROCKEN ZU LAGERN--VOR FROST ZU SCHÜTZEN. UMGANG BEI OFFENER FLAMME VERMEIDEN. SICH VON KINDER FERNZUHALTEN--GEFAHRLICH ZU ESSEN.

GEHALT: 12 TUBE JEDO MIT 14 PLATZCHEN
(168-ER PACKUNG) U.S.A. — ERZEUGNIS.

THE NELSON PAINT COMPANY
IRON MOUNTAIN, MI. 49801
MONTGOMERY, AL. 36108 • McMINNVILLE, OR. 97128

Nelson



MARKING PELLETS

BAND INDICATES COLOR

APPENDIX E

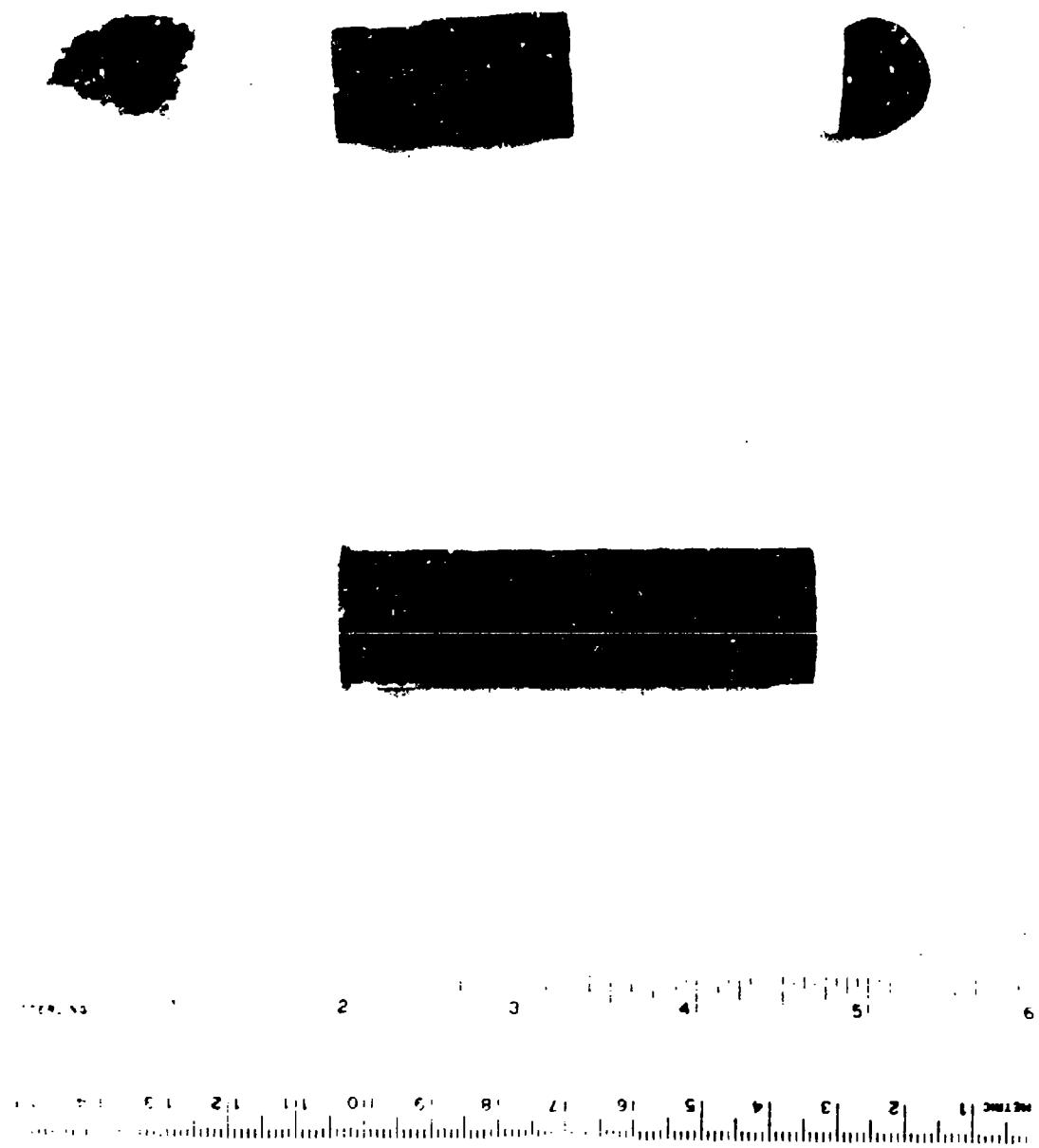


Figure 1. 12 Gauge Liquid Ball, Round and Components.

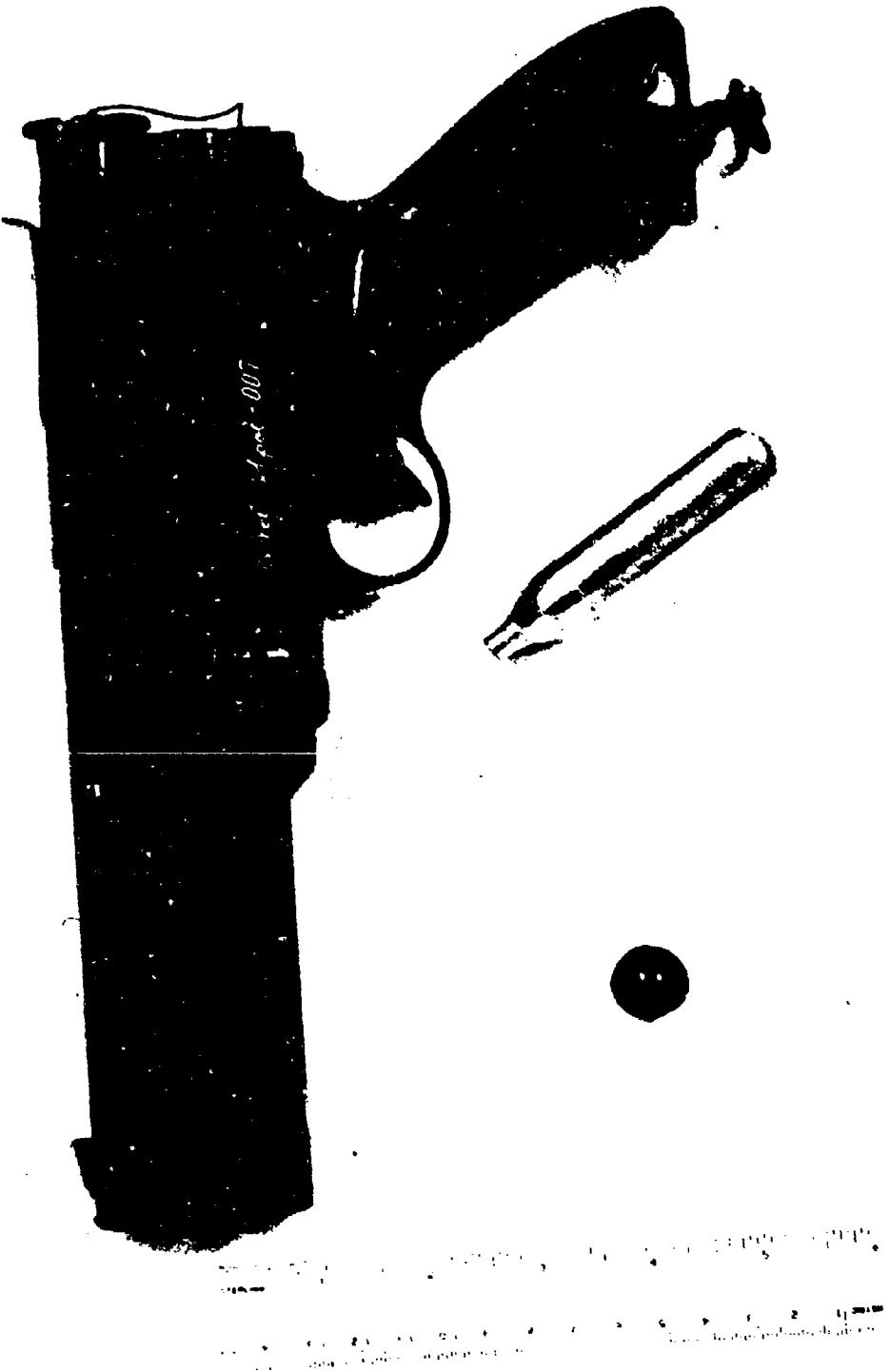


Figure 2. Nel Spot 007 CO₂ Pistol Power Charge
and Nelson Marking Pellet Projectile.

40

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Figure 3. Round Number 16. Microflash, 12 Gauge Liquid Ball Projectile & Wad.

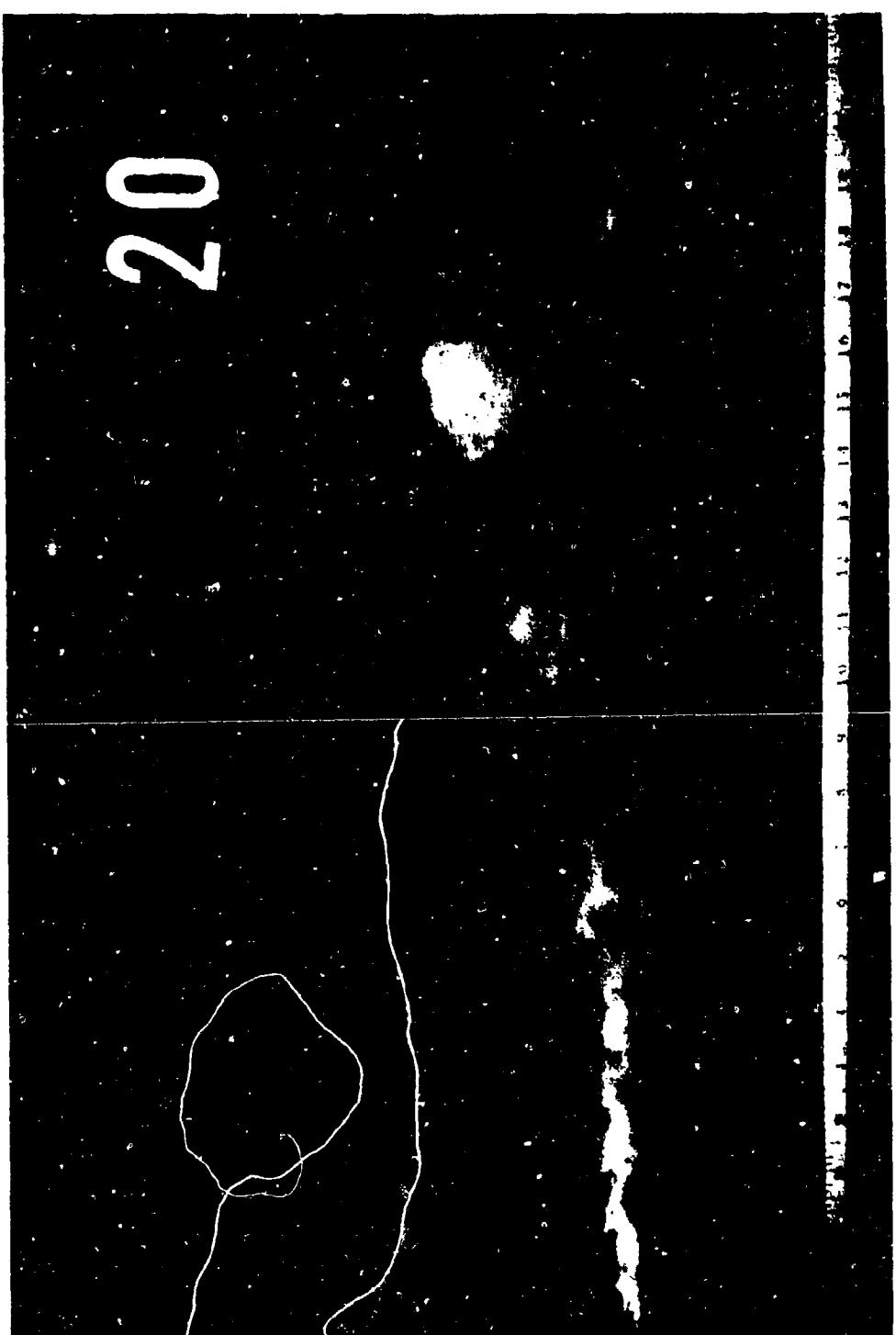


Figure 4. Round Number 42. Microflash, Nelson Marking Pellet Fired from a "Nel-Spot" 007 CO₂ Pistol.

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Figure 5. Round Number 43. Microflash, Nelson Marking Pellet Fired from a "Nel-Spot" 007 CO₂ Pistol.

39

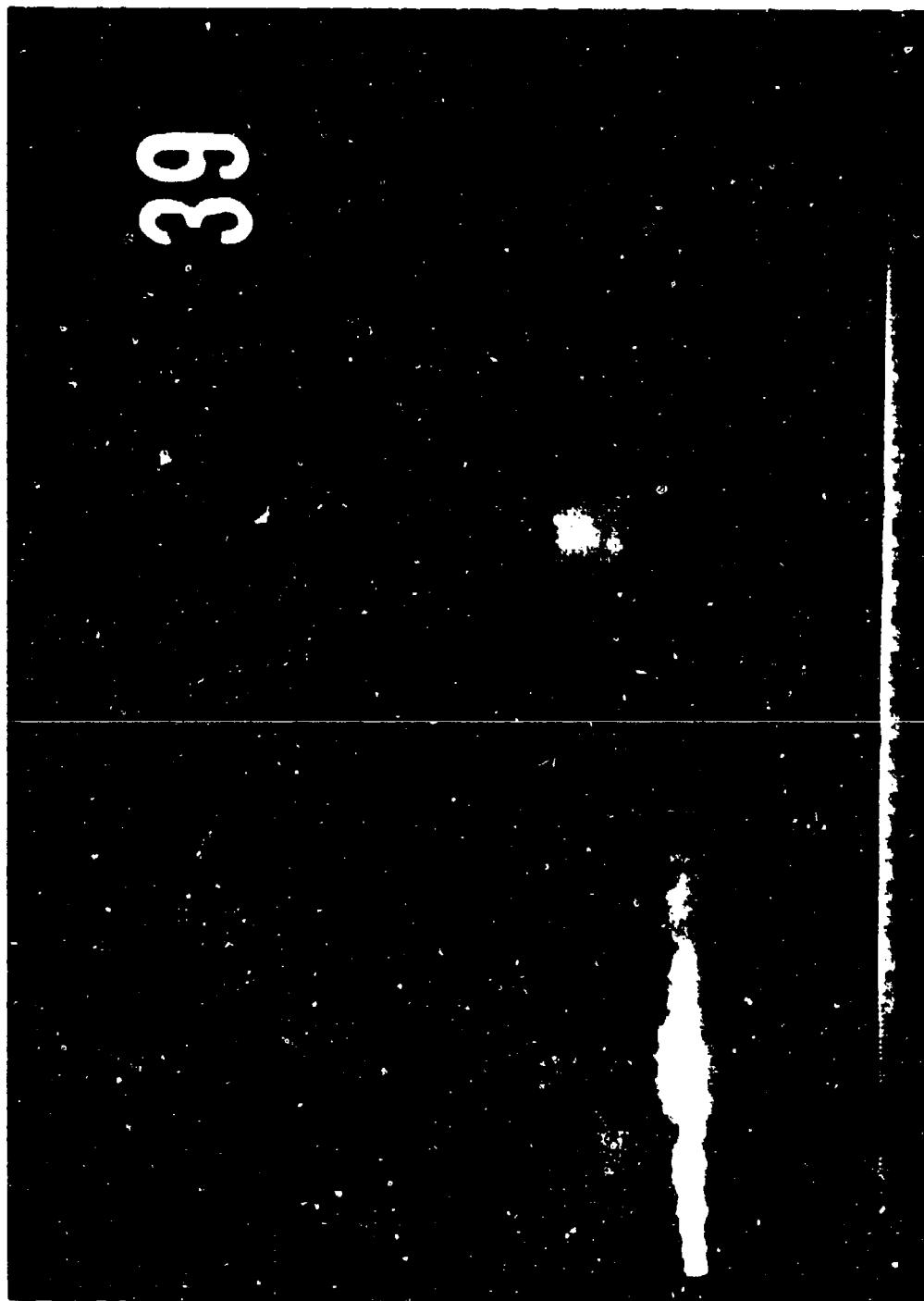


Figure 6. Round Number 44. Microflash, Nelson Marking Pellet Fired from a "Nel-Spot" 007 CO₂ Pistol.

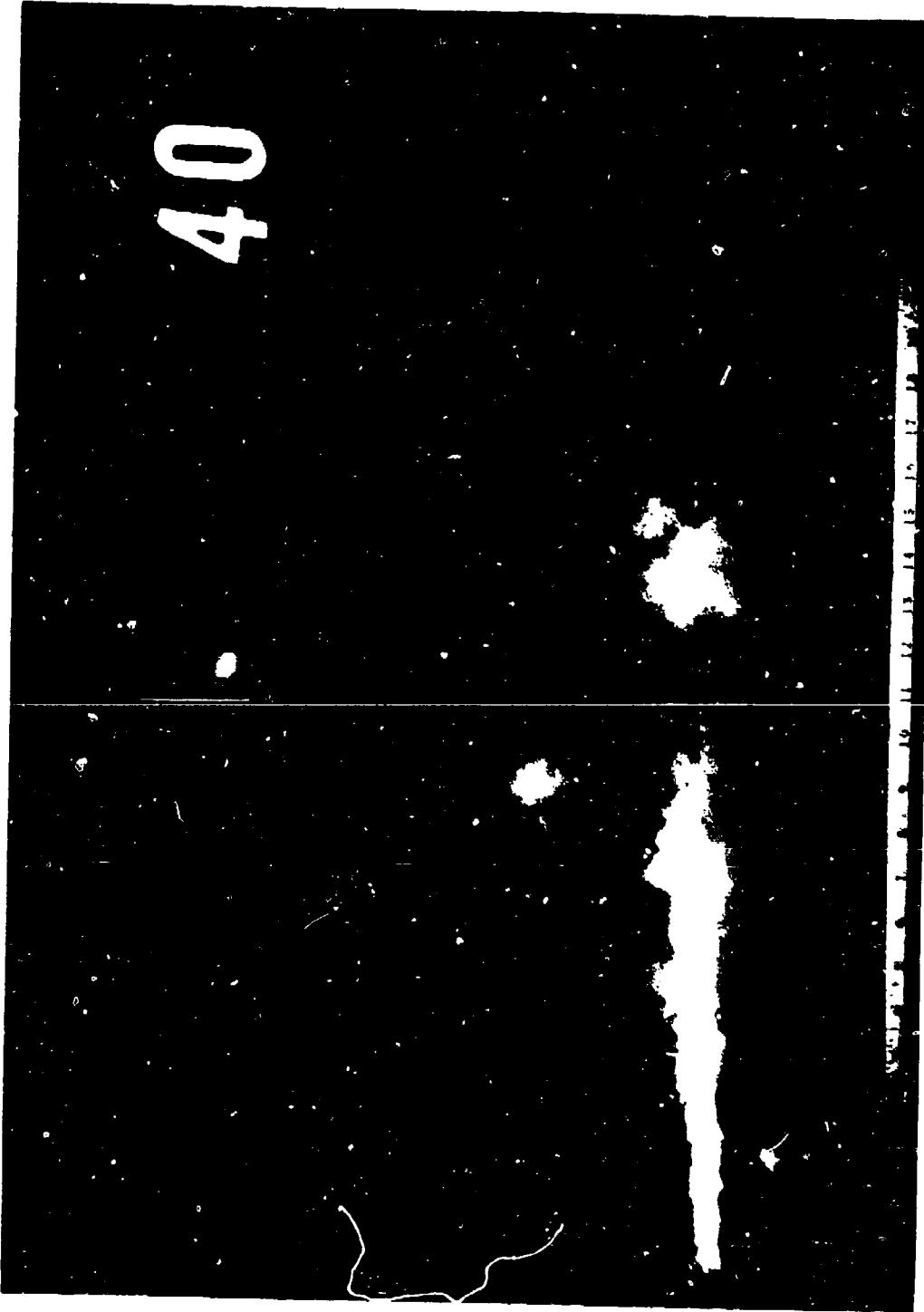


Figure 7. Round Number 4S. Microflassi, Nelson Marking Pellet Fired from a "Ne1-Spot" 007 CO₂ Pistol.